

PERCEPTION

VOLUME 41

SUPPLEMENT

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ECVP 2012

35th European Conference on Visual Perception

2 – 6 September 2012, Alghero – Italy

Abstracts

35th European Conference on Visual Perception

Alghero, Italy

2–6 September 2012

Abstracts

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ECVP 2012 Abstracts

SUNDAY

SYMPOSIUM: 100 YEARS OF GOOD GESTALT: NEW VISTAS**◆ How good Gestalt determines low level vision**

M Herzog (EPFL, Switzerland; e-mail: michael.herzog@epfl.ch)

In classical models of vision, low level visual tasks are explained by low level neural mechanisms. For example, in crowding, perception of a target is impeded by nearby elements because, as it is argued, responses of neurons coding for nearby elements are pooled. Indeed, performance deteriorated when a vernier stimulus was flanked by two lines, one on each side. However, performance improved strongly when the lines were embedded in squares. Low level interactions cannot explain this uncrowding effect because the neighboring lines are part of the squares. It seems that good Gestalts determine crowding, contrary to classical models which rather predict that low level crowding should occur even before the squares, ie higher level features, are computed. Crowding and other types of contextual modulation are just one example. Very similar results were also found for visual backward and forward masking, feature integration along motion trajectories and many more. I will discuss how good Gestalts determine low level processing by recurrent, dynamic computations, thus, mapping the physical into perceptual space.

◆ A century of Gestalt theory: The good, the bad, and the ugly

J Wagemans (University of Leuven [KU Leuven], Belgium;

e-mail: johan.wagemans@psy.kuleuven.be)

100 years ago Wertheimer published his paper on phi motion, widely recognized as the start of Gestalt theory. I will evaluate what it has offered to modern vision science. (1) The good: The emergence of structure in perceptual experience and the subjective nature of phenomenal awareness remained central topics of research. Using methods and tools that were not at the Gestaltists' disposal, much progress was made in outlining principles of perceptual grouping and figure-ground organization. (2) The bad: Gestalt theory was criticized for offering mere demonstrations with simple or confounded stimuli, and formulating laws with little precision for every factor that influenced perceptual organization. Köhler's electrical field theory was proven wrong and the underlying notion of psychophysical isomorphism not productive. Claims about Gestalt principles being preattentive, innate, and independent of experience appeared exaggerated. (3) The ugly: Several Gestalt notions do not fit well with the rest of what we know about vision. How can we understand the relationships between parts and wholes in light of the visual cortical hierarchy and dynamics? How can internal laws based on a general minimum principle yield veridicality in the external world? Establishing an integration of Gestalt theory within modern vision science provides serious challenges.

◆ Understanding perceptual organization: What, how, and why?

S Palmer (University of California, Berkeley, USA; e-mail: sepalmer@gmail.com)

Koffka famously asked why things look the way they do. I will argue that answering it entails answering at least two important additional questions: what things look like and how they come to look that way. Gestalt psychologists answered the what-question by producing and discussing phenomenological demonstrations of geometrical image features (eg, proximity and similarity of elements in grouping and surroundedness and small size of regions in figure/ground perception), the how-question by hypothesizing holistic brain processes that settle into minimum-energy states, and the why-question by appealing to simplicity (Prägnanz). I will contrast this classical Gestalt approach with modern approaches to perceptual organization based on behavioral, neuroscientific, and ecological methods. I will argue that direct behavioral reports of phenomenology are epistemologically primary to other kinds of evidence and thus indispensable. I will also characterize several important developments in answering the why-question as involving the explication of ecological factors that support the perception of environmental surfaces, much as expected from making Helmholtzian unconscious inferences.

Sunday

◆ **Gestalt influences in modal and amodal filling-in**

R van Lier (Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, Netherlands; e-mail: r.vanlier@donders.ru.nl)

Whatever we see, its appearance belongs to the output of the perceptual system. Time and again it appears that relatively simple stimulus manipulations reveal extraordinary perceptual output—with varying degrees of phenomenological presence. The brain appears to fill in various properties that cannot be directly derived from the retinal image. With respect to that process, a distinction has often been made between modal and amodal filling-in. This modal-amodal dichotomy particularly holds for the phenomenological appearance of the filled in properties. Regarding brain processes, however, this distinction is much less obvious; especially amodal filling-in can be situated in a “grey zone”, somewhere in between seeing and thinking. Here Gestalt principles of visual organization may compete with influences of higher level aspects such as knowledge and familiarity. I will review recent studies on various filling-in phenomena and show how they help to understand the underlying mechanisms of perception.

◆ **Amodal completion and shape approximation**

W Gerbino (University of Trieste, Italy; e-mail: gerbino@units.it)

With few exceptions (Fantoni et al, 2008, *Vision Research* **48** 1196–1216; Fulvio et al, 2009 *Journal of Vision* **9**(4) 5 1–19) the amodal completion of angles has been conceived as the production of a trajectory that interpolates veridically represented input segments. This is the case also for the Gerbino illusion, originally explained as the consequence of amodal additions based on good continuation (Gerbino, 1978 *Italian Journal of Psychology* **5** 88–100). Alternatively, amodal completion might involve approximation. Curve fitting by polynomial functions makes the difference clear (Ullman, 1996 *High-level Vision*, MIT Press). Interpolation generates a curve that connects all points and minimizes the changes of direction; approximation generates a curve that minimizes the distances from points, with a variable error intrinsic to noisy data. In the Gerbino illusion approximation generates a smooth hexagon that cannot match the arrangement of input segments, given the coincidental occlusion of vertices. Fantoni et al (2008) provided evidence of approximation in amodal completion of 3D surfaces. With reference to such phenomena I will discuss the assumption that perceptual experience includes representations not only of the optic input but also of the degree of mismatch between the input and approximated shapes.

◆ **On grouping and shape formation: new results**

B Pinna (Dept of Architecture, Design and Planning, Italy; e-mail: baingio@uniss.it)

The problem of perceptual organization was first studied by Gestalt psychologists in terms of grouping/segmentation by asking “how do individual elements group into parts that in their turn group into larger wholes separated from other wholes?”. The aim of this work is to use gestalt psychologists’ insights to answer the following questions: What is shape? What is its meaning? How does it pop out from grouping? What is the relationship between grouping and shape? Shape perception and its meaning were studied starting from the square/diamond illusion and according to the phenomenological approach traced by gestalt psychologists. The role of frame of reference in determining shape perception was discussed and largely weakened or refuted in the light of a high number of new effects, based on some phenomenal meta-shape properties useful and necessary to define the meaning of shape. On the basis of new illusions, it is suggested that the meaning of shape can be reconsidered as a multiplicity of meta-shape attributes that operate like meaningful primitives of the language of shape perception. Through these results, limits and advantages of the gestalt approach to perceptual organization within modern Vision Science are discussed.

◆ **Shading gradient based cues to depth and figure-ground perception**

T Ghose¹, S Palmer² (¹University of Kaiserslautern, Germany; ²University of California, Berkeley, USA; e-mail: tandraghose@gmail.com)

Rubin (1921) first identified the problem of figure-ground organization (FGO) in ink-blot like images and isolated several factors (cues) that influence the process. Since then, for almost 75 years similar flat-2D bipartite displays were used to investigate FGO leading to the identification of many more cues to FGO, until very recently, border ownership was discussed in asymmetrical luminance profiles in the watercolor illusion. However, none of the studies, thus far had discussed the role of important information provided by shading and texture gradients that are available in natural and artificial images. I will discuss the FGO cues of Extremal Edges and Gradient Cuts that exploit the regularity in shading gradients and influence the interpretation of images because they reflect the structure of bounded surfaces in the 3D

world. I will also discuss how the discovery of such “powerful” cues to depth and FGO opened up ways to studying important open questions in FGO that were not possible with the “weaker” Gestalt cues (eg, recent study by Brooks and Palmer, 2011 *Journal of Cognitive Neuroscience* **23**(3) 631–644).

◆ **Definition of shape**

Z Pizlo¹, Y Li¹, Y Shi¹, T Sawada¹, R Steinman² (¹Purdue University, USA; ²University of Maryland, USA; e-mail: pizlo@psych.purdue.edu)

Gestalt Psychology made shape perception important 100 years ago but we still do not know what shape is. Most assume that all patterns and objects have shape. This is unsatisfactory because our commonsense and perceptions tell us that a random-dot-pattern has less shape than a butterfly. Today, we propose a new analytical definition of shape, based on the amount of symmetry it contains. Symmetry, here, is understood broadly, ie, as any type of spatial regularity, measured by its self-similarity. This definition makes it possible to classify objects along a one-dimensional shape continuum, with amorphous objects, such as bent-wires, crumpled papers and potatoes having little, even zero, shape. Implications derived from our definition can explain: (i) why shapes are perceived veridically; (ii) how the shapes of non-rigid, as well as rigid objects, can be handled; (iii) how content-addressable memory for shapes can be organized, and (iv) how informative a priori shape constraints (priors) allow veridical perception of unfamiliar shapes. Note that our “shapes” are measured by applying the Minimum Description Length Principle, making it a modern version of the Gestalt Law of Prägnanz. It is also similar to Leeuwenberg’s Structural Information Theory.

◆ **A pluralist approach to Gestalts**

P van der Helm (University of Leuven, Netherlands; e-mail: p.vanderhelm@donders.ru.nl)

According to the law of Prägnanz, Gestalts result from a nonlinear process: like any physical system, the brain tends towards relatively stable neural states characterized by cognitive properties such as symmetry, harmony, and simplicity. This idea has led, initially, to representational approaches modeling those cognitive properties, and later, to dynamic-systems approaches modeling those neural states. Not surprising, this modeling duality triggered a controversy about which of these two kinds of approaches might be the better one. Now, however, it is time to realize that these two kinds of approaches are complementary, and that both stories are needed to tell the whole story. Future research may reveal whether the two complementary stories remain different or can be merged into one story, but a bridging function may be played by connectionism—not so much because of its theoretical ideas, but rather because of the modeling tools it borrowed from mathematics.

SYMPOSIUM: A SYMPOSIUM TO HONOUR TOM TROSCIANKO

◆ **Seeing through Tom’s eyes: perception of isoluminant chromatic contours**

M W Greenlee¹, L Spillmann² (¹Institute of Experimental Psychology, University of Regensburg, Germany; ²University of Freiburg, Germany; e-mail: mark.greenlee@psychologie.uni-regensburg.de)

Certain aspects of vision are altered for isoluminant chromatic contours: spatial phase discrimination, Vernier offset acuity, apparent motion, velocity discrimination of moving contours and the Ouchi illusion. Tom Troscianko studied all of these phenomena and reported most of his results in a set of papers published in 1987–1988 (Troscianko 1987 *Vision Research* **27**(4) 547–554; Troscianko and Fahle 1988 *Journal of the Optical Society of America A* **5**(6), 871–880; Troscianko and Harris, 1988 *Vision Research* **28**(9) 1041–1049). Tom suggested that the breakdown in visual performance (or the reduced illusory jitter in the Ouchi figure) was related to greater positional uncertainty of isoluminant chromatic contours. Tom attributed the uncertainty to a lack of inhibitory surrounds in postreceptoral mechanisms that encode isoluminant edges. We review Tom’s work on perception at isoluminance and discuss to what extent research over last 25 years provides support for his early and insightful observations.

◆ **The motion of pure colour: it’s all in the jitter**

P Cavanagh, M Wexler (Université Paris Descartes, France; e-mail: patrick.cavanagh@parisdescartes.fr)

Among Tom Troscianko’s many interests, he had an extended affair with pure colour stimuli, running many studies on their fascinating effects like slowed motion, and their jazzy, unstable appearance. Tom, always an iconoclast, did not buy the fashionable arguments that motion was colour-blind and argued instead that isoluminant stimuli acted as ordinary luminance stimuli but with positional jitter. He

Sunday

attributed this spatial scrambling to the larger positional uncertainty of early color-selective units. He then showed that spatial scrambling can produce all reported effects of isoluminant stimuli: apparent slowing, loss of global shape in kinematograms, slowed reaction times, whereas spatial jitter preserved properties not lost at isoluminance, such as symmetry perception. It followed, according to Tom, that isoluminant visual displays do not isolate real, higher-level chromatic mechanisms, as performance was first of all contaminated by this low-level jitter. As an indication that the motion contribution from color was not a property of high-level chromatic pathways, Tom, together with several others, showed that motion responses to isoluminant stimuli survived in brain-damaged patients that saw no color at all. He then developed techniques to isolate pure-color responses by adding uncorrelated dynamic luminance noise to the isoluminant display, extending the rationale of the Ishihara plates. He was able to show that a weak motion response survives even this superimposed noise field. Together with Mark Wexler in Paris, we are now extending Tom's ideas about position jitter to new motion phenomena for luminance and colour-defined stimuli.

◆ **From stereo vision over isoluminance to perceptual learning**

M Fahle¹, T Troscianko² (¹Bremen University, Germany; ²Bristol University, UK;
e-mail: mfahle@uni-bremen.de)

I will outline three topics Tom and I worked on together—stereo and colour vision, both in healthy subjects and in patients—and relate them to my recent work on perceptual learning. (1) On stereo vision, a topic Tom had touched hardly at all before and never again after our article, we identified retinal image quality, spatial frequency, luminance, contrast, temporal factors, motion, size and retinal location as factors constraining stereo vision. (2) On motion perception at isoluminance, we were able to explain the slow-down experienced subjectively at isoluminance of moving colour stimuli by decreased positional accuracy, rather than by a lack of temporal accuracy. We suggested that isoluminant stimuli behave like low-contrast non-isoluminant stimuli and successfully modeled the results accordingly. (3a) The study of two patients suffering from achromatopsia questioned the traditional view that colour information is carried exclusively by colour-opponent parvocellular channels, concluding that chromatic discrimination can be subserved by a non-parvocellular channel. (3b) Testing patients after peripheral retinal detachment, we found isoluminant flicker fusion frequencies being severely decreased even though anomaloscope results were normal, demonstrating the potential of isoluminant stimuli for clinical tests. The improvement, over time, in these patient's performance, started my interest in perceptual learning.

◆ **The colour opponency assumptions in a V1-based model for predicting perceived differences in natural scenes**

D Tolhurst¹, R Rajani², T Troscianko³, I Gibson² (¹University of Cambridge, UK; ²University of Cambridge, UK; ³University of Bristol, UK; e-mail: ig266@cam.ac.uk)

We are developing a V1 based computer model to explain observers' suprathreshold judgments of the perceived magnitude of differences between naturalistic images (Lovell et al, 2006 *ACM TAP* 3 155–178; To et al, 2010 *Journal of Vision* 10(4):12, 1–22). We now question some of the fundamental assumptions within the model, particularly the formulations of the Red-Green and Blue-Yellow colour opponent processes. Presently, we use a Macleod-Boynton transform which assumes (i) that R/G opponency is only between L and M cones and (ii) that colour opponent changes are coded totally independently of luminance. Then, isoluminant L/M and S-modulated sinewave gratings (Mullen, 1985 *Journal of Physiology* 359 381–400) map directly and separately into the R/G and B/Y mechanisms. However, there is much evidence that the R/G system also includes input from S-cones, while the S-cone in the B/Y system might be synergistic with L or M cones. The assumption of isoluminance is questionable. We have conducted rating magnitude experiments to estimate the perceived differences between isoluminant 3.8 degrees square patches differing in hue in L*c*h space by 10, 20 or 30 degrees. The perceived difference depends highly on the patch luminance, falsifying our basic assumption that the colour opponent planes in our model are isoluminant.

◆ **What task drove the evolution of human colour vision?**

P Sumner¹, A Bompas², G Kendall² (¹Cardiff University, UK; ²Cardiff University, UK;
e-mail: sumnerp@cf.ac.uk)

The red-green dimension of human colour vision appears to be optimized for finding fruit in leaves at about arms reach (Parraga, Troscianko and Tolhurst, 2002), but is this 'picking fruit' task the one where trichromacy provides the largest advantage over red-green colour blindness? Other authors had assumed

that spotting a fruiting tree at distance (between trees) was key. We tested this directly in a naturalistic setting by asking trichromats and dichromats to spot fruit pieces in bushes at different distances. We found that performance diverged with distance from 4m to 12m—ie the advantage of trichromacy grows with distance. Interestingly however, for the shortest distance (1 m) the advantage of normal colour vision also appears greater than at 4 m. Thus both theories (arms-length and between-tree) may be right.

◆ **Cuttlefish coloration—tricks of camouflage and show**

D Osorio¹, S Zylinski² (¹University of Sussex, UK; ²Duke University, USA;
e-mail: d.osorio@sussex.ac.uk)

Cuttlefish draw together a number of Tom's interests on natural images, camouflage, illusions and lighting. We will present an overview of this fascinating creature and new findings that illuminate the cuttlefish's art.

◆ **When the eyes predict judgments about real moving scenes**

I D Gilchrist¹, C J Howard², T Troscianko¹ (¹University of Bristol, UK; ²Nottingham Trent University, UK; e-mail: I.D.Gilchrist@bristol.ac.uk)

Our visual environment changes continuously and so in turn do our judgments. In a series of studies we developed a set of methods to study this dynamic relationship and to investigate if fixation behavior could give an insight into the link between the changing visual world and our changing judgments. In one experiment participants watched a video of a football match and indicated the likelihood of an imminent goal with a joystick. We found that the variability of fixation position across participants was related to judgments of imminent goal likelihood. Participants tended to be fixating the same part of the video as one another a few seconds before they increased their reported likelihood of a goal. We also found that experts got their eyes to the relevant parts of the scene earlier. In subsequent work we investigated participants making a continuous suspiciousness judgment while viewing a set of four CCTV videos. We found that the eyes were directed to the video with the highest level of reported relative suspiciousness. The methods we developed open up the possibility of studying a wide range of tasks in which the visual stimuli are complex and dynamic and the judgment is continuous.

◆ **Examining attention allocation in multiplex viewing: How many scenes are seen?**

M Stainer¹, B Tatler¹, K C Scott-Brown² (¹University of Dundee, UK; ²University of Abertay, UK; e-mail: b.w.tatler@dundee.ac.uk)

Multiplex displays are a popular visualisation tool in entertainment and professional use. Most research examines how attention is allocated in single scene viewing, but multiplex displays present the visual system with a number of additional challenges. Perhaps nowhere are the demands of viewing such displays more evident than in the CCTV Control Room where operators can be required to simultaneously monitor up to 100 scenes. In a series of experiments we examine attention allocation across the multiplex and tease apart several potential causes of processing difficulty. Using a modified version of the flicker paradigm with multiple scenes containing a single changed item, we use change detection performance as an index of attention allocation. Unsurprisingly, change detection performance decreases as scene number increases. There are many potential reasons for this difficulty with multiplex arrays. Across a set of experiments we show that performance is influenced by the information content of the multiplex rather than semantic similarity between scenes or the physical continuity of content across scenes. The underlying factors governing attention allocation in multiplex displays appear surprisingly similar to those for single scene viewing, raising questions about whether a multiplex of scenes is treated perceptually as a single scene.

◆ **The perception of correlation in datasets**

R Rensink (Dept of Psychology, UBC, Canada; e-mail: rensink@psych.ubc.ca)

Humans are remarkably good at getting the gist of a scene from a quick glance. Can this ability be used in the visualization of complex datasets? It will be shown that the perception of correlation in scatterplots is rapid, being largely complete within 150 ms of presentation. This process can be characterized by two simple laws: a linear Fechner-like law for precision and a logarithmic Weber-like law for accuracy. Results show a surprising degree of invariance for scatterplot symbol: different sizes, colours, and shapes have little effect on precision or accuracy. Other forms of visualization exhibit similar patterns. These results suggest that correlation perception is a sophisticated process, likely playing an important role in rapid scene perception. At a more general level, they also suggest that information visualization can be a useful domain in which to study visual cognition.

Monday

MONDAY**SYMPOSIUM: A VISION FOR OPEN SCIENCE**◆ **Does rewarding that which is easily measured lead to better science?**

L De-Wit (University of Leuven, Belgium; e-mail: lee.dewit@ppw.kuleuven.be)

The transition to a more open model of doing science will involve numerous technical challenges in terms of how we can most effectively make code, data and published material cheaply and efficiently available. Beyond these technical challenges, however, we will also need to reflect on the optimal culture for facilitating good research. I will argue that the current culture is problematic, because researchers' energy and time is so consumed by the short-term 'publishing papers, to get grants, to publish papers' cycle that we don't have time to pursue solutions that could make our research more useful and important in the long term. One of the primary causes of this 'publish or perish' culture is a shift in higher education to rewarding output that is easy to quantify. Informally many academics agree that this reward model, and the culture that it promotes, are sub-optimal; the question, of course, is how we can change it. This talk will speculate on a number of options for broadening the way in which scientists are rewarded for their contributions to science (in particular for peer review), and actions we can take as individual researchers to challenge this culture and reward model.

◆ **Why have so many academics decided to boycott Elsevier?**

N Scott-Samuel (University of Bristol, UK; e-mail: n.e.scott-samuel@bris.ac.uk)

On 1 February 2012, I posted a message to CVNet expressing doubts about whether I should be reviewing for journals which weren't open access. My message was prompted by the coincidence of a request to review a paper for *Vision Research*, and an increasing flurry of negative media coverage about Elsevier, its publisher. There were around 60 replies to my original post, some of which came back to me (rather than CVNet) with a request for anonymity. In the wake of the discussion on CVNet, I signed the online petition at thecostofknowledge.com, which allows individuals to state that they will refrain from publishing in and/or refereeing and/or carrying out editorial work for Elsevier journals. I will explain why I decided to do this, and also hypothesise as to why almost 10,000 other researchers (as of April 2012) have done the same thing.

◆ **Open access and author-owned copyright**A Kenall¹, T Meese², P Thompson³ (¹Pion, UK; ²Aston University, UK; ³University of York, UK; e-mail: amye@pion.co.uk)

What are the barriers to starting an open-access journal? Much has been discussed about cost, and there are now more than a few successful production models one can point to. But what are the other barriers, the barriers to starting any new journal? For example, financing and developing a journal reputation. We offer some "notes from the field" from our experience with launching the open-access journal *i-Perception*. The second half of our talk focuses on author-owned copyright. We argue that the natural place of copyright is with the author and explain some reasoning behind various publishers' positions on copyright and permissions. Also, how might these policies be affected by various developments in public funding of research?

◆ **Publication bias, the File Drawer Problem, and how innovative publication models can help**

D Apthorp (University of Wollongong, Australia; e-mail: dapthorp@uow.edu.au)

One of the topics that has come up frequently in the discussions on open science has been the "file-drawer problem", otherwise known as publication bias (Rosenthal, 1979 *Psychological Bulletin* **86**(3), 638–641). Traditional publishing practices have tended to favour positive results that reject the null hypothesis, leading some researchers to suggest that, in the extreme case, "most published results are false" (Ioannidis, 2005 *PLoS Medicine* **2**(8), e124). What does this mean for vision science, and how can an open science framework help address this problem? I will suggest that innovative publishing initiatives such as PsychFileDrawer.org and the Reproducibility Project can harness the new technologies available to researchers to encourage replication of important published research. In addition, new publication models could use methods similar to the registration of all clinical trials in medicine (eg initial peer review of only the Introduction and Methods) to help lessen or abolish publication bias.

◆ **Open experiments and open source**

J Peirce (University of Nottingham, UK; e-mail: jon@peirce.org.uk)

Have you ever tried to replicate someone's study and found that they didn't include sufficient detail for it to be possible? Or wanted to extend someone's study, but avoided it because it was too much effort to generate their stimuli? Have you learned a new software language and wanted some working scripts to get started? Open science isn't only about providing people with access to our findings. In the interests of both replicability and education, we should also be striving to provide full access to our actual experiments. This talk will focus on how we might encourage the sharing of experiment code as well as looking at the related movement of open-source software development for science.

◆ **Exploiting modern technology in making experiments: the academic app store**

I M Thornton (Swansea University, UK; e-mail: i.m.thornton@swansea.ac.uk)

During the last decade, the commercial model for distributing software has undergone a complete revolution. Inspired by the success of music and video download sites, many companies now focus on volume sales of small, stand-alone applications or "apps" rather than on expensive software suites. Important factors behind this shift have been then rapid increase in processing power available on mobile devices, such as smart phones and tablets, and the consequent changes in how users prefer to interact with software. In this talk, I want to explore what these changes might mean for scientists in terms of the development and distribution of experimental ideas. In short, there are numerous open source environments that make it make it relatively easy to take existing experimental code and to produce cross-platform apps that can be freely downloaded both by academic colleagues and potential participants. Whether such 'experimental apps' are designed to run on standard desktop hardware or are specifically focused on the novel interface and data capture potential of mobile devices, there could be a number of advantages to adopting such a model. Here I will specifically focus on rapid development, quick and easy distribution, and the potential for mass, remote data collection.

SYMPOSIUM: COMPUTATIONAL APPROACHES TO VISUAL ILLUSION

◆ **Impossible motions: a new type of visual illusion generated by shape-from-image equations**

K Sugihara (Meiji University, Japan; e-mail: kokichis@isc.meiji.ac.jp)

A new type of visual illusion, which we call "impossible motion" is presented. In this illusion, we are given a solid object which looks like an ordinary shape, but motion added to the object will generate an impression that such motion cannot arise because they are against physical laws. Examples are balls rolling uphill along slopes defying the gravity law, and rods penetrating through two or more windows simultaneously defying straightness of the rods. These illusions are generated by utilizing the degrees of freedom in the choice of three-dimensional solid structures from two-dimensional images. For a given image of a familiar solid object, humans usually perceive one solid object, although there are infinitely many solid structures which yield the same image. Utilizing this gap between human perception and geometric constraints, we can cheat humans, thus designing "impossible motion". We present many examples of impossible motion, and try to elucidate a nature of human perception of solid structures from two-dimensional images, in which some structures are preferred to others. In particular we present a hypothesis that human vision prefers highly symmetric structures, and show that the illusion of impossible motion can be explained by this hypothesis.

◆ **Shape-free hybrid image effects of artificial noise and complementary color**

P Sripian, Y Yamaguchi (University of Tokyo, Japan; e-mail: yama@graco.c.u-tokyo.ac.jp)

We present a new scheme for generating a shape-free hybrid image, an image that changes interpretation according to the viewing distance. A hybrid image is created by the combination of the low and the high spatial frequencies of two source images. It is based on human visual perception which perceives up to some range of spatial frequency at a specific visual angle. Our methods allow the construction of hybrid image regardless of the source image's shape. Without the need to carefully pick the two images to be superimposed, a hybrid image can be extended to use with any kind of image contents. We propose two approaches to accomplish shape-free hybrid image, which are noise-inserted approach and color-inserted approach. Noise-inserted approach forces observers to perceive alternative low frequency image as meaningless noises in a close viewing distance, by manipulating contrast and details in the high frequency image and also by pre-process both source images before extracting spatial frequencies. Color-inserted approach attracts visual attention for the high frequency image perception by using complementary chromatic sinusoidal gratings. Finally, hybrid image recognition experiments prove that

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our proposed method yield a better recognition rate over the original method while preserving hybrid image characteristic.

◆ **Perceptual stabilization of ambiguous visual input: a synthesis of perception, computation and neurophysiology**

C Klink (Netherlands Institute for Neuroscience, Netherlands; e-mail: p.c.klink@gmail.com)

Ambiguous visual stimuli contain sensory evidence for two (or more) mutually exclusive perceptual interpretations. While perceptual awareness is dominated by a single interpretation at any particular moment, dominance tends to alternate between different interpretations over prolonged viewing time. These dominance fluctuations can however be slowed down significantly by presenting ambiguous stimuli in sequences of brief presentation periods separated by interstimulus periods without visual input. The neural mechanisms that determine perceptual dominance at stimulus onset and the dynamics of perceptual alternations may help us understand the basic neuronal operations of perceptual organization. Here we present results from computational modeling, human psychophysical experiments, and neurophysiological recordings from monkey visual cortex, all aimed at understanding these mechanisms. The original computational work yielded the hypothesis that dynamics of perceptual dominance should crucially depend on the temporal profile of stimulus presentation. Behavioral experiments confirmed this hypothesis, refined the computational model and provided a handle for neurophysiological recordings. Data from these recordings revealed a range of effects on neuronal response variability that push the computational framework towards incorporating intra- and intercellular neuronal dynamics.

◆ **Illusions in man and machine**

C Fermuller (University of Maryland, USA; e-mail: fer@cfar.umd.edu)

From a computational point of view, many of the processes involved in the interpretation of images are estimation processes and can be analyzed using the tools of statistics and signal processing. Through analyses of early visual computations we found intrinsic limitations in many processes, which make it impossible to compute veridical estimates in all imaging situations. Specifically, we found three principles governing the estimation of static image features and image motion. These are (a) statistical biases affecting the estimation of all image features, which can account for many geometric optic illusions and motion patterns such as the Ouchi illusion; (b) asymmetry in the filters computing temporal derivatives, which can account for illusory motion in patterns with asymmetric intensity signal such as the Snake illusion; (c) effects from compression of the signal, which can account for errors in the estimation of lightness and color illusions. Since these limitations are inherent to the computations, we argue, that they will affect artificial as well as biological systems. To understand these limitations, can help us improve our machine vision methods when they are designed for constrained environments.

◆ **Computational creation of a new illusionary solid sign with the hollow structure**

A Tomoeda (Meiji University, Japan; e-mail: atom@isc.meiji.ac.jp)

We present a new illusionary solid sign, so-called “hollow arrow sign”, inspired by two kinds of illusions; “hollow mask illusion” and “crater illusion”. This illusionary sign creates a visual illusion in such a way that the depth of the solid is inversely perceived for one’s eyes due to the illumination direction. Moreover, the hollow sign appears to move in the same direction as the observer when he / she changes his / her observation point. In general, the productions to provide the visual illusion are obtained on an empirical basis. However, anyone can create this kind of the illusionary solid sign that is a solid sign with the hollow structure by our computational method to obtain the three-dimensional vertices of the illusionary solid.

TUESDAY

SYMPOSIUM: NEURAL OSCILLATIONS IN VISUAL PERCEPTION AND SELECTIVE ATTENTION◆ **The role of alpha-band oscillatory activity in voluntary attentional control across sensory modalities: An assessment of supramodal attention theory.**S Banerjee¹, A Snyder², S Molholm¹, J Foxe¹ (¹ Albert Einstein College of Medicine, USA;² University of Pittsburgh, USA; e-mail: john.fox@einstein.yu.edu)

Oscillatory alpha-band activity (8–15 Hz) over parieto-occipital cortex in humans plays an important role in voluntary attentional control, with increased alpha-band power observed over cortex contralateral to locations expected to contain distractors. The parietal lobes are prominent generators of alpha oscillations, raising the possibility that alpha is a neural signature of spatial attention across sensory modalities. Here, we asked whether lateralized alpha-band activity was also evident in a purely audio-spatial cueing task and whether it had the same underlying generator configuration as in a purely visuospatial task, which would provide strong support for “supramodal” attention theory. Alternately, alpha-band differences between auditory and visual tasks would support a sensory-specific account. We found lateralized alpha-band activations over parieto-occipital regions for both tasks, yet clear differences in scalp topographies depending on the sensory system within which spatial attention was deployed. Findings suggest that parietally-generated alpha-band mechanisms are central to attentional deployments across modalities, but that they are invoked in a sensory-specific manner. In a following study, we observed that pure voluntary attentional control in the absence of attention-directing cues enhanced early activations in visual cortices. These studies develop robust metrics for voluntary attentional control, and implications for understanding the neural mechanisms of attentional disorders.

◆ **Oscillatory markers of perceptual decision formation under vigilant monitoring conditions**S Kelly¹, R O’Connell² (¹ City College New York, USA; ² Trinity College Dublin, Ireland;

e-mail: skelly2@ccny.cuny.edu)

We are often required to maintain focus on a continuous task that is perceptually trivial, but involves detection of events that are intermittent, unpredictable, and that lack physical salience—for example, monitoring the proximity of flanking cars on the highway. This cognitive ability, known as vigilant attention, is one of the hardest to study in the laboratory, because the discrete events that we normally use to elicit behavioral and neurophysiological responses are inherently salient, undermining the role of vigilance. We have recently developed a new supramodal continuous-monitoring paradigm that enables continuous electrophysiological (EEG) tracking of perceptual, cognitive and motor processes in parallel over prolonged periods, by exploiting well known oscillatory amplitude effects. While observers monitor for gradually emerging targets defined by changes in a single stimulus feature, we track the encoding of that feature in stimulus-driven steady-state activity (21 Hz), we track accumulated evidence via parietal alpha activity (8–14 Hz), and track motor preparation via lateralized beta (22–30 Hz), allowing a unique view on attentional fluctuations at each of these distinct processing stages that have direct consequences for the timing and accuracy of detection decisions.

◆ **Alpha rhythms echo the world inside the brain and make it flicker**

R Vanrullen (CNRS, France; e-mail: rufin.vanrullen@cerco.ups-tlse.fr)

The alpha rhythm (8–13 Hz) is the largest oscillatory signal that can be recorded from the awake human brain. What is it good for? Current thinking is that it serves an inhibitory purpose: it decreases upon visual stimulation, it is smaller in cortical areas that receive attentional enhancement and higher in those areas that receive suppression. This view implies that when there is alpha, you don’t see much, and vice-versa. I will show two recent results from our laboratory that suggest otherwise. First, alpha rhythms were found to echo a random visual stimulation sequence in the brain for about 1 second—alpha was thus positively related to visual processing. Second, alpha can induce an illusion of perceptual flicker for a particular static stimulus (a wheel with 32 spokes, viewed in the periphery)—in other words, the consequences of alpha oscillations can sometimes be perceptually experienced. I will conjecture that alpha rhythms, although inhibitory by nature, do not abolish perception; rather, they temporally shape the stream of perceptual experience.

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◆ **Dynamic alpha re-mapping during pro- and anti- saccade tasks: common rapid oscillatory mechanisms during both overt and covert attentional deployments**

D Belyusar¹, A C Snyder¹, H Frey¹, M R Harwood², J J Foxe¹ (¹The Cognitive Neurophysiology Laboratory, Children's Evaluation and Rehabilitation Center, Depts of Pediatrics and Neuroscience, Albert Einstein College of Medicine, Bronx, New York, USA; ²Dept of Biology, City College of the City University of New York, New York, USA; e-mail: belyusar@gmail.com)

Previous research on the role of attention in visual tasks has tended to use experimental designs in which alpha rhythms have been shown to slowly modulate over a 1–2 second cue-task interval. However, overt attention, as exemplified by the saccadic eye movement system, can shift several times per second. While some electrophysiological evidence has suggested a common mechanism for shifting both covert attention and eye movements (Kustov, Robinson, 1996 *Nature* **384**(6604) 74–77) other results favor unique cortical mechanisms (Eimer, Van Velzen, Gherri, Press, 2007 *Brain Research* **1135**(1), 154–66). To address these conflicting results, we considered a known electrophysiological correlate of covert attention in an anti-saccade paradigm in which participants need to suppress lateralized exogenous cues, in order to quickly move their eyes to the opposite side. Previous research has shown changes in alpha-band (8–14Hz) power correlate with preparatory states, such that increases in alpha levels are associated with active suppression of unattended targets. Our results similarly indicate differential parieto-occipital alpha-band modulations to both cue and target location, to both auditory and visual cues. Results demonstrate rapid shifts in alpha power to cue onset, and later to saccade-related lateralization under 300ms. These phases appear topographically similar across the scalp regardless of stimulus modality suggesting an exciting new role for alpha rhythms in both sensory and motor processes.

◆ **Alpha-band rhythms in visual task performance: Phase-locking by sensory stimulation, and relation to encephalographic activity**

G Thut (University of Glasgow, UK; e-mail: g.thut@psy.gla.ac.uk)

An event in one sensory modality can phase-reset brain oscillations concerning the same or another modality. This may result in stimulus-locked periodicity in behavioral performance cycling at the frequency of the phase-reset oscillation. My talk will consider this possible impact of sensory events for one of the best-characterized rhythms of the visual system, the alpha-oscillations. In one experiment, we presented rhythmic visual cues at different frequencies and tested their impact on subsequent visual target detection (unimodal impact) at cued and uncued positions. We found a breakdown of cueing benefits for 10Hz-stimulation (in the alpha-band) in comparison to stimulation at flanker frequencies. In addition, 10Hz-stimulation led to an alpha-rhythm in visual task performance post-cueing. In another experiment, we presented a brief sound and found again a periodic pattern in visual task performance post-sound (crossmodal impact) cycling at alpha-frequency. In both experiments, the sinusoidal pattern of visual performance correlated in frequency across individuals with resting encephalographic alpha-oscillations over occipital areas. This indicates that (i) brain oscillations have been entrained/time-locked by the sensory event, and that (ii) this can be used to reveal cyclical influences of brain rhythms on perception to study their functional roles, here in line with rapid alpha-cycles underlying periodic visual sampling.

◆ **Cortical cross-frequency coupling dramatically affects performance during a taxing visual-detection task**

I Fiebelkorn¹, A Snyder², M Mercier¹, J Butler¹, S Molholm¹, J Foxe¹ (¹Albert Einstein College of Medicine, USA; ²University of Pittsburgh, USA; e-mail: ian.fiebelkorn@einstein.yu.edu)

Functional networks are comprised of neuronal ensembles bound through synchronization across multiple intrinsic oscillatory frequencies. Various coupled interactions between brain oscillators have been described (eg, phase-amplitude coupling), but with little evidence that these interactions actually influence perceptual sensitivity. Here, electroencephalographic recordings were made during a sustained-attention task to demonstrate that cross-frequency coupling has significant consequences for perceptual outcomes (ie, whether participants detect a near-threshold visual target). Our results reveal that phase-detection relationships at higher frequencies are entirely dependent on the phase of lower frequencies, such that higher frequencies alternate between periods when their phase is strongly predictive of visual-target detection and periods when their phase has no influence whatsoever. These data thus bridge the crucial gap between complex oscillatory phenomena and perceptual outcomes. Accounting for cross-frequency coupling between lower (ie, delta and theta) and higher frequencies (eg, beta and

gamma), we show that visual-target detection fluctuates dramatically as a function of pre-stimulus phase, with performance swings of as much as 80 percent.

SYMPOSIUM: COLOUR COGNITION

◆ The blue area requires multiple colour names in Italian

G Paramei, C Stara (Liverpool Hope University, UK; e-mail: parameg@hope.ac.uk)

The blue area of colour space arguably requires more than one basic colour term (CT) in Italian (Paggetti et al, 2011 *Attention, Perception & Psychophysics*, 73, 491–503). This proposition was addressed in a colour mapping task employing Munsell 7.5 BG-5 PB charts to explore the frequency and consistency of CTs used by Italian speakers compared to English speakers. Participants were Italian monolinguals ($N=13$; Sassari), English monolinguals ($N=13$; Liverpool) and Italian–English bilinguals ($N=13$; Liverpool); the latter completed the task in both languages. Munsell chips were labelled using the unconstrained colour naming method. Participants then indicated the best example (focal colour) of frequent monolexic CTs (eg turquoise, blue for English; turchese, azzurro for Italian). For these, ‘3D Munsell maps’ were constructed. Italian speakers were found to require at least three CTs, with the most frequent and consistent use of celeste ‘light blue’, azzurro ‘medium blue’ and blu ‘dark blue’. Compared to the English focal blue, the Italian focal blu appeared to be darker. Notably, in bilinguals it was shifted towards the English focal blue, with the extent of the shift related to proficiency in English and duration of immersion in the UK (cf Athanasopoulos, 2009, *Bilingualism: Language and Cognition* 12, 83–95).

◆ A method to study colour category

A Logvinenko (Glasgow Caledonian University, UK; e-mail: a.logvinenko@gcu.ac.uk)

If there are perceptual colour categories which are not reduced to the verbal categories, then a problem is how to look into these perceptual categories not resorting to verbal names, labels and the like. I suggest to use a method which is based on the same idea as the partial hue-matching technique developed recently. The results of some preliminary experiments will be reported.

◆ How invariant is unique white?

S Wuerger¹, K Xiao¹, E Hird¹, T Chauhan¹, D Karatzas², E Perales³ (¹University of Liverpool, UK; ²Universidad Autónoma de Barcelona, Spain; ³University of Alicante, Spain; e-mail: estpero@gmail.com)

Despite the theoretical importance of unique white, there is little agreement on its precise chromaticity. Often an equal-energy white (CIE $x=0.33$; $y=0.33$) is assumed (Werner and Shiffrin, 1993 *Journal of the Optical Society of America* 10(7), 1509–1516.) which is close to ecologically relevant illuminations, such as the sun’s disk ($x=0.331$; $y=0.344$) and daylight (D65: $x=0.313$; $y=0.329$). Here we test the invariance of these unique white settings under changes in illumination, task and luminance. Stimuli were displayed on a CRT on a black background and ambient illumination was controlled by a Verivide luminaire. White settings were obtained ($n=30$) under dark viewing conditions, under D65 ($x=0.312$ $y=0.334$), and under CWF ($x=0.394$ $y=0.387$), using three different tasks: adjustment along the daylight locus, along the axes in LUV space, or along the unique hue lines. We find that the average unique white point (under dark viewing conditions) is located at CIE $x=0.292$, $y=0.303$, which is at a significantly higher colour temperature than daylight. Changing the illumination from dark to D65 (CWF) shifted the white point towards D65 (CWF). We conclude that observers are able to provide accurate but illumination-dependent unique white settings. Implications for different adaptation models will be discussed.

◆ Category effects for red and brown

C Witzel, K R Gegenfurtner (Giessen University, Germany; e-mail: christoph.witzel@psychol.uni-giessen.de)

Red and brown are particular colour categories: Their member colours are comparatively dark and change category membership with increasing lightness to orange and pink, respectively. Moreover, brown is neither a unique nor a binary hue, and seems to be only defined through language. Brown also appears much later during colour term acquisition. We investigated category effects for the red-brown category boundary. We established the red-brown boundary through a naming task, measured discrimination thresholds for colours across the boundary, and performance in a visual search task with colour pairs that were equalised in discriminability based on the empirical discrimination thresholds. We found that there is no change of discrimination thresholds at the boundary. In contrast, there was a

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boost of performance (lower reaction times, accuracy twice as high) for identifying colour differences in equally discriminable colour pairs, when the colours cross the boundary. These category effects were not lateralised at all. These results are completely in line with those shown for colours at moderate lightness levels. Given the particularity of brown, these results further underpin the idea that category effects are due to a shift of attention to the linguistic distinction between categories rather than being a pure product of perception.

◆ **Locating colors in the Munsell space: an unconstrained color naming experiment**

G Paggetti, G Menegaz (University of Verona, Italy; e-mail: gloria.menegaz@univr.it)

A previous study (Paggetti et al, 2011 *Attention, Perception & Psychophysics* **73**(2), 491–503) based on a constrained color naming experiment on Italian subjects suggested the need of a twelfth basic color term (BCT) within the blue category. Though, it is still controversial whether constraining the subject's answers would introduce a bias on the subject's performance and thus lead to erroneous conclusions. For this reason, a second color naming experiment was performed following the unconstrained method. In order to overcome some limitations of the OSA–UCS system used previously, the Munsell system was adopted. The two main objectives of this work were to identify color classes and color names during an unconstrained color naming task and to compare the outcomes with those obtained following the constrained method. Two sets of measures were extracted for characterizing each color term (consistency and consensus) and color category (centroid and focal colors). Results support the conclusions driven from the previous study suggesting that the Italian language features twelve BCTs. This study contributed to identify color classes as defined by Italian speakers during unconstrained color naming, as well as to the definition of the positions of focals, centroids, consistency and consensus colors in the Munsell system.

WEDNESDAY

SYMPOSIUM: MOVING IMAGE–MOVING EYES: ACTIVE VISION IN THE REAL WORLD◆ **The role of eye movements in real world human navigation**

S Durant¹, J Zanker² (¹Royal Holloway University of London, UK; ²Royal Holloway, University of London, UK; e-mail: j.zanker@rhul.ac.uk)

Recovering our heading direction based on visual information requires interpreting optic flow, the pattern of motion caused by our movement through the world. This is affected by head stability and the direction of eye gaze. We investigated how eye movements interact with head movements whilst walking forward. An observer navigated through a variety of environments around the university campus using a head mounted device that simultaneously recorded the scene ahead and tracked eye movements, allowing us to determine the gaze direction in each frame. This resulted in an image sequence as recorded by the camera, and by realigning the images to keep eye fixation location fixed at the same point, we could mimic the input received by the retina. We found that eye movements were usually focused towards the heading direction when not scanning the scene. Local motion direction and magnitude was calculated for the two types of image sequences to analyze the optic flow patterns. In some scenes eye movements appeared to compensate to some extent for head movement, challenging the general view that eye movements complicate optic flow retrieval. Our results suggest that the role of compensatory eye movements might be important in the calculation of heading direction.

◆ **Eye guidance in natural vision**

B Tatler (University of Dundee, UK; e-mail: b.w.tatler@dundee.ac.uk)

The human behavioural repertoire is intricately linked to the gaze control system: many behaviours require visual information at some point in their planning or execution. Moreover, the spatial and temporal restrictions imposed by foveal vision and saccadic eye movements mean that high acuity vision needs to be allocated appropriately in both space and time. How we allocate vision when viewing complex static scenes has been researched extensively and there exist effective computational models of fixation selection for such circumstances. However, it is not clear whether understanding from static scene-viewing paradigms generalizes to more natural behavioural settings. General principles that appear to underlie targeting decisions during natural behaviour are evident across a range of behaviours. These principles identify the components of eye movement behaviour that any models of fixation selection in natural behaviour must be able to explain. Reward maximization provides a powerful potential framework for explaining eye movement behaviour, but formal models of this are in their infancy.

◆ **Eye movements in reading as the expression of distributed spatial coding in oculomotor-centre maps**

F Vitu (LPC, CNRS, Aix-Marseille Université, France;
e-mail: Francoise.Vitu-Thibault@univ-provence.fr)

Eye movements in natural perceptual tasks are classically considered to reflect ongoing cognitive processes as well as pre-established visuo-motor scanning routines aimed at optimizing visual-information intake and/or motor action. Here, I will argue against this assumption for the particular case of reading, providing empirical evidence for the alternative assumption that eye behaviour in reading is for a great part the expression of distributed spatial coding in oculomotor-centre maps (ie the superior colliculus). First, I will show that the general tendency for the eyes to land near the centre of long words as well as variability around this preferred landing position comes from the more basic tendency to land at the centre of gravity of the visual configuration in the periphery, also referred to as global effect (Findlay, 1982 *Vision Research* **22** 1033–1045). Second, I will present recent data from our group showing that the deformation of visual space in oculomotor-centre maps constrains both the metrical properties of saccades in simple saccade-target tasks as well as eye movements in reading.

◆ **Eye movements in interception**

E Brenner¹, J B J Smeets² (¹VU University, Netherlands; ²Faculty of Human Movement Sciences, VU University, Amsterdam, Netherlands; e-mail: j.smeets@fbw.vu.nl)

People generally try to keep their eyes on a moving target that they intend to catch or hit. I will discuss several reasons why they may want to do so. We studied this issue by designing interception tasks that promote different eye movements. When the task was to hit a moving target, we found that people's hits

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were less precise if they did not pursue the target. If the task was to hit the target at a certain position, they were better at getting the position right if they did not pursue the target. Comparing these two tasks, after matching them in their overall perceptual requirements, showed that pursuing the target has an additional benefit. We ascribe this additional benefit to information about the pursuit eye movements themselves. Thus, improving the resolution of visual information that is gathered during the movement for continuously improving predictions about critical aspects of the task, such as anticipating where the target will be at some time in the future, may not be the only reason for keeping one's eyes on the target. I will discuss some other possible benefits.

◆ **Learning to use the lightfield for shape and lightness perception**

J M Harris¹, P G Lovell¹, G Harding², M Bloj³ (¹University of St Andrews, UK; ²University of Bradford, UK; e-mail: m.bloj@bradford.ac.uk)

To infer shape and lightness from illumination gradients, the visual system must understand the relationship between the illumination and the environment in which the object is located (dubbed "the lightfield"). Here we explored the importance of actively learning the lightfield. Realistically rendered scenes depicted objects with complex illumination gradients. We explored two learning paradigms. One where the object moved through a number of shape configurations before shape perception was tested. The other paradigm involved observers actively moving objects within a lightfield before lightness judgments were made. Our results suggested that observers are able to use illumination gradients to make consistent shape judgments, if they are given a short learning period, where they experience the object moving through all possible shape configurations. In the lightness study, we found that lightness constancy could best be achieved when observers experienced the lightfield during a systematic learning period. In sum, our work suggests the importance of active learning of the environment in the interpretation of lightness and shape via gradient cues.

◆ **Reading unstable words in dyslexia: inefficiency of saccade-vergence neuroplasticity**

Z Kapoula (CNRS, France; e-mail: zoi.kapoula@gmail.com)

We have recently shown that saccades from dyslexic teenagers during reading are abnormally disconjugate; their eyes are drifting disconjugately during fixations causing vergence errors and highly variable fixation disparity. Dyslexics are thus confronted to unstable letters interfering with reading. Are these problems a consequence of reading difficulty? We think not, as similar abnormalities exist for saccades to single targets. We suggest that the motor learning mechanisms controlling saccade-vergence interaction remain inefficient in dyslexia. Here we examine whether variability of fixation disparity increases during the 5min of reading test (due to fatigue or reading difficulty). No time effect was found neither for dyslexics nor for controls, suggesting that the differences between groups are constitutive. In another study we measure disconjugacy of saccades and fixations in a mindless reading task: the text is transformed to X's except a target letter C in the middle of each string. Dyslexic teenagers are requested to fixate successively each letter C. The results show again abnormal disconjugacy, similar to that during text reading. Thus, the deficit of vergence control causing saccade and fixation disconjugacy seems to be primary and needs to be addressed first. Whether reading difficulty especially over long periods accentuates disconjugacy needs further investigation

SYMPOSIUM: VISUAL, MOTOR, AND ATTENTIONAL ASPECTS OF DYSLLEXIA

◆ **A causal link between visual attention span and reading acquisition**

S Valdois¹, M Bosse² (¹CNRS, France; ²Université Joseph Fourier, France; e-mail: Sylviane.Valdois@upmf-grenoble.fr)

The question has been hotly debated whether developmental dyslexia resulted from a language problem (a phonological disorder) or a visual impairment. We have introduced the concept of visual attention (VA) span to account for the poor reading outcome of a subset of dyslexic children who show preserved phonological skills. It has been shown that the VA span is reduced in a subgroup of dyslexic children and that this disorder relates to atypical activation of the superior parietal lobules. VA span abilities further contribute to reading performance in both dyslexic and non-dyslexic children, independently of their phonological skills. However, the available data are not strong evidence for a causal relationship. We will report data from a longitudinal study carried out on 130 children who were assessed twice in kindergarten and at the end of 1st grade. Their VA span, phonological skills, verbal short-term memory, letter name and letter sound knowledge, and reading abilities were measured in kindergarten

and considered as potential predictors of their reading performance one year later. Structural equation models showed that pre-reading VA span accounts for a significant and proper amount of variance in reading one year later, after controlling for the other predictive factors. Our findings show that VA span abilities in prereaders predict future reading acquisition, thus suggesting a causal link between poor VA span and poor reading outcome in developmental dyslexia.

◆ **The magnocellular theory of visual dyslexia**

J Stein (Oxford University, UK; e-mail: john.stein@dpag.ox.ac.uk)

Of the 10% of children who find it unexpectedly difficult to learn to read fluently despite normal intelligence, health and education (developmental dyslexia), many have impaired development of visual magnocellular neurones. This impairs their ability to see letters and words properly. Magnocellular neurones are responsible for directing visual attention and eye movements during reading, hence for accurately sequencing letters. This new understanding of the visual processing problems in dyslexia has enabled the development of novel and effective remedial treatments, such as coloured filters and fixation training. Impaired development of magnocells is partly genetic, partly associated with autoimmunity and aggravated by lack of essential micronutrients, in particular omega-3 fatty acids derived from oily fish.

◆ **Spatial attention and learning to read: Evidence from a 3-years longitudinal study**

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Developmental dyslexia is a neurobiological disorder that affects about 10% of the children. Although impaired auditory and speech sound processing is widely assumed to characterize dyslexic individuals, emerging evidence suggests that dyslexia could arise from a more basic cross-modal letter-to-speech sound integration deficit. Nevertheless, letters must be precisely selected from irrelevant and cluttering letters by rapid shifting of visual attention before the correct letter-to-speech sound integration is applied. Thus, is prereading visual parietal-attention functioning able to explain future reading emergence and development? The present 3-years longitudinal study shows that prereading attentional shifting ability—assessed by serial search performance and spatial cueing facilitation—captures not only future basis of reading skills (ie, rapid letter naming and pseudoword length effect) but also words and text reading abilities in grades 1 and 2 after controlling for speech-sound processing as well as nonalphabetic crossmodal mapping. Our results provide evidence that visual spatial attention efficiency in preschoolers specifically predicts future reading acquisition, suggesting new approaches for early identification and a more efficient prevention of developmental dyslexia.

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MONDAY**TALKS: 3D PERCEPTION I**◆ **Perceived slant of rectangular grids viewed on slanted screens**

C Erkelens (Utrecht University, Netherlands; e-mail: c.j.erkelens@uu.nl)

A fundamental question in vision is how 3D perception is inferred from 2D images. Many studies showed that monocular and binocular sources of information (cues) contribute to perceived depth and 3D shape. To test contributions of individual cues, several laboratories have measured perceived slants induced by single and combined, ie disparity and perspective-related, cues. The consensus of these studies is that observers combine cues in a statistically optimal fashion. Optimal cue combination does not explain 3D perception in pictures and 2D movies. Disparity would strongly reduce perceived depth during binocular viewing. To investigate the effect of a screen on slant perception, I measured slants of rectangular grids that were viewed binocularly on a screen placed on a turntable. Slant of the computed grids and slant of the screen were varied independently. Subjects indicated perceived slant by orienting a physical rectangular surface placed on another turntable. The judgments show that the slant of the screen does not affect the perceived slant of the grids. The conclusion is that slant perception of a grid on a screen is based on perspective-related cues. Disparity and monocular cues related to the screen are fully suppressed.

◆ **Binocular fusion, suppression and diplopia: effects of disparity, contrast polarity and contrast imbalance**

S Wallis, M Georgeson (Aston University, UK; e-mail: m.a.georgeson@aston.ac.uk)

With different images to each eye, one may experience fusion, suppression of one eye's view, or diplopia. To understand better the underlying binocular processes, we studied perception of binocular edges as a function of binocular disparity. Single, Gaussian-blurred, horizontal edges (blur $B = 8$ min of arc) were shown to each eye at various vertical disparities (0 to $8B$), with the same or opposite contrast polarity. Observers could indicate the position and polarity of a single perceived edge, or report 2 edges. Diplopia increased with disparity, but when contrasts were unequal the lower-contrast edge was often not seen, particularly at disparities 3 to $5B$. We developed a simple descriptive model to interpret the behavioural responses as arising from (a) the probability of fusion (assumed to fall with increasing disparity), (b) the probability of suppression occurring when fusion fails, and (c) the role of positional noise and criterion in judgments of edge position. From this modelling, we conclude that fusion extends to disparities of about $2.5B$ for all observers, but is absent for opposite polarities. Probability of suppression also declined monotonically with increasing disparity, increased with contrast imbalance, and tended to be lower for opposite polarities, but was highly variable across observers.

◆ **Nonlinear binocular summation and interocular suppression implement binocular fusion: a unification of two models**

M Georgeson, S Wallis (Aston University, UK; e-mail: s.a.wallis2@aston.ac.uk)

A striking feature of binocular vision is that different images in the two eyes can be 'fused' in perception, yet little is known about how fusion is achieved. We studied fusion and diplopia for Gaussian-blurred, horizontal edges with vertical disparity (silencing stereo vision). For a wide range of blurs B , the range of fusion is about $2.5B$. If fusion linearly summed or averaged the monocular signals, we should expect fused edges to look increasingly blurred as disparity increased. In a blur-matching task, we found that this was true when the two edges were physically added (monocular control), but for dichoptic edges perceived blur was nearly invariant with disparity. We show that such fusion, preserving blur, occurs if luminance gradients are computed for each eye, and then the two Gaussian gradient profiles are combined as a contrast-weighted geometric mean. Finally, we show that this model for fusion is almost exactly equivalent to our earlier two-stage model derived from experiments on binocular and dichoptic contrast discrimination (Meese, Georgeson, and Baker, 2006 *Journal of Vision*). The binocular interactions proposed there can now be seen to implement the contrast-weighted geometric mean, and thus to achieve blur-preserving binocular fusion, followed by signal compression.

◆ **Depth constancy and frontal-plane scaling in the absence of vertical disparities**

B Rogers (University of Oxford, UK; e-mail: bjr@psy.ox.ac.uk)

Binocular disparities vary inversely with the square of viewing distance and therefore scaling is needed in order to achieve depth constancy. Scaling is also needed to correct for the differing patterns of horizontal

disparities created by frontal-plane surfaces at different distances. Both vergence and differential perspective (vertical disparities) have been shown to provide scaling information (Rogers and Bradshaw, 1995 *Perception* 24) but the extent of constancy is much higher for frontal-plane judgments. This has been attributed to the fact that a distance estimate is not required because there is frontal-plane information in the vertical and horizontal disparity fields. This idea was tested using stimuli that provided no vertical disparity information. Observers made frontal-plane judgments using a narrow (2 deg high x 70 deg wide) textured strip while simultaneously adjusting the amplitude of a narrow (2 deg wide x 60 deg high) strip of horizontally-oriented, triangular corrugations until the ridge angles appeared to be 90 deg. Vergence was varied between 0 deg (0cm) and 13 deg (29cm) in different trials. Scaling was more complete (70–80%) in observers' frontal-plane judgments compared with the depth task which produced only ~30% of the required scaling. Cue-conflicts cannot account for the results since the two tasks were done under the same stimulus conditions.

◆ **Phantom contours in da Vinci stereopsis**

B Gillam, S Wardle (University of New South Wales, Australia; e-mail: b.gillam@unsw.edu.au)

It is now known that monocular regions in binocular arrays are informative about depth in a number of ways. For example a monocular region attached to a binocular surface can appear occluded by the surface if on its temporal side and camouflaged against it if on its nasal side. Depth magnitude varies with the width of the attachment. We showed using a binocular probe that in the camouflage case, seeing the attachment in depth requires that it have the same luminance and colour as the background surface. When a nasal attachment did not satisfy camouflage conditions a phantom occluder was seen on its nasal side "accounting for" its monocular status. The magnitude of the depth seen in the phantom was as precise and accurate as regular stereopsis. No depth was seen in the surface itself. This outcome implies double matching—of the edge of the binocular region in one eye with both the edge of the binocular region and the edge of the monocular region in the other eye—a novel form of Panum's limiting case. These findings are not compatible with several theories of Panum's Limiting Case and show that accurate/precise stereopsis does not require a contour to carry depth.

◆ **Broad spatial tunings of the object aftereffect: Evidence for global statistical representations of 3D shape and material**

I Motoyoshi (NTT Communication Science Laboratories, NTT, Japan; e-mail: motoyoshi.isamu@lab.ntt.co.jp)

We recently showed that adaptation to a 3D object with a particular shape (eg, bumpy) and material (eg, glossy) alters the appearance of the subsequent object (eg, smooth and matte; Motoyoshi, 2012, Vision Sciences Society). Notably, this object aftereffect is also induced by adaptation to a random noise having a similar spatial frequency with the adapting object, indicating an impact of simple image statistics in the perception of 3D shape and material. To test if this is consequent to local feature coding in early levels, we here examined spatial tuning of the aftereffect. Following adaptation for 40 s (4-s top-up) to a pair of two band-pass noises with different amplitudes, a pair of realistic spherical objects with different bumpiness were presented for 250 ms at various locations. Observers judged which object appeared bumpier, and the PSE was estimated. We found robust aftereffects (~30% of those at the adapting location) even for objects presented 12 deg away from the adapting noises (~3.5 deg in radius). Similar results were obtained for glossiness. These findings manifest the existence of high-level visual mechanisms that represent 3D shape and material as summary image statistics within a very large receptive field.

◆ **Apparent motion in depth: first attempts**

N Wade (University of Dundee, UK; e-mail: n.j.wade@dundee.ac.uk)

The new wave of stereoscopic movies has stimulated interest in the old wave which started it. The combination of simulated motion and depth required three prior stages of invention: apparent motion, stereoscopy and photography. The origins for all these can be found in the decade after 1825, mostly in London but also in Paris. Instruments were devised which simulated motion and depth: sequences of slightly different still images could appear to move and paired pictures (with small horizontal disparities and presented to different eyes) were seen in depth. In 1831, Faraday's experiments on persisting images provided the impetus for Plateau's phenakistiscope and Stampfer's stroboscopic disc (both in 1833). Daguerre and Talbot described their techniques for capturing light on metal or paper in 1839. Wheatstone invented the stereoscope in 1832, directed Talbot to take paired photographs for use with it in 1840, and suggested how sequences of stereoscopic photographs could be combined in the phenakistiscope (in a

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letter to Plateau in 1849). This last was attempted by Claudet in London and Duboscq in Paris in the early 1850s with the fantascopic stereoscope and bioscope, but their efforts were not rewarded. Motion was easier to simulate than motion in depth.

◆ **The role of stereopsis in figural grouping versus segmentation**

L Deas, L M Wilcox (Centre for Vision Research, York University, Canada;
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The disparity required to discriminate the relative depth of a pair of isolated vertical lines is minute but increases dramatically when these lines are connected to form a closed figure (McKee, 1983 *Vision Research* **23** 191–198). Here we propose that the loss of sensitivity in the closed configuration is due to within-object depth averaging. We tested this proposal by measuring discrimination thresholds for neighbouring vertical lines in a set of four equally spaced lines that produced three adjacent test pairs (left, central, right). We created two closed rectangles by connecting the outer pairs of lines, and measured thresholds for the same line pairs. Note that now in the central pair condition the lines formed sides of separate rectangles. As expected, thresholds were lower for isolated lines than for their closed counterparts. Importantly, thresholds were also lower in the central condition, when the line pairs belonged to distinct objects. Our results suggest that sensitivity to binocular disparity depends critically on figural grouping. Specifically we hypothesize that the high-resolution disparity signal helps segregate one object from another, and that this resolution is sacrificed (possibly via disparity averaging) to reinforce object cohesiveness.

TALKS: COLOUR PERCEPTION

◆ **Chromatic adaptation concomitantly displaces a subjective category boundary and a locus of enhanced discrimination**

J Mollon¹, M Danilova² (¹Cambridge University, UK; ²I P Pavlov Institute of Physiology, Russian Federation; e-mail: jm123@cam.ac.uk)

A fundamental boundary in colour space is that between reddish and greenish hues. Under neutral conditions of adaptation (to a field metameric to Illuminant D65), chromatic discrimination is optimal near this category boundary (Danilova and Mollon, 2010 *Journal of Vision* **10**(8) 4, 1–9). However, it has long been established that adaptation to a non-neutral field will displace the subjective boundary in chromaticity space (eg Wei and Shevell, 1995 *Journal of the Optical Society of America A* **12** 36–46). We ask whether there will be a concomitant shift in the locus of optimal discrimination. Using a two-alternative spatial forced choice, we measured discrimination thresholds for foveal fields subtending 2°. Brief (150 ms), bipartite targets were presented on neutral or coloured fields, and thresholds were measured along lines approximately orthogonal to the red-green boundary. In separate, interleaved runs, the subjective hue boundary was measured empirically for each condition and for each observer. The subjective hue boundary and the locus of optimal discrimination were shifted concomitantly by chromatic adaptation, a result suggesting they share a neural basis. [Support: RFBR 12–04–01797-a, The Royal Society International Exchanges IE110252.]

◆ **Effects of contour frequency and amplitude on the strength of the Watercolor Effect**

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The Watercolor Effect is a long-range, filling-in phenomenon induced by a pair of distant, wavy contours of complementary chromaticities. Here, we measured the influence of the contour frequency and amplitude and the luminance of the interior contour on the strength of the effect. Contour pairs (8 min width for each), each enclosing a circular region (4 deg diameter), were presented with two of the dimensions varying at once (luminance/frequency; luminance/amplitude; frequency/amplitude) in a conjoint measurement paradigm (Ho et al, 2009 *Psychological Science* **19**(2)). On each trial, observers judged which of the stimuli evoked the most salient fill-in color. Control stimuli were identical except that the contours were braided and generated little filling-in. Perceptual scales were estimated by a maximum likelihood method. As shown previously using a difference scaling paradigm (Devinck and Knoblauch, 2012 *Journal of Vision* **12**(3)), the strength increases with luminance of the interior contour. The strength of the phenomenon was independent of the amplitude of the undulation but increased with the frequency up to an asymptotic level. An additive model accounted for the joint contributions of

luminance and frequency. The strength of the luminance effect was comparable to that observed using difference scaling, suggesting that these distinct paradigms are mediated by a common neural process.

◆ **Color information processing in early visual analysis**

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The visual system extracts rapidly the most important elements of the external world from a large flux of information, using early and intensive data reduction. If and how color information is used at this stage is still unknown. A recent model of early visual processing predicts —the features that human observers exploit for discrimination of compressed representations (sketches). (Del Viva et al, 2010 *Journal of Vision* **10**(7), 1360);—that color does not provide a significant improvement in the information content of such sketches, compared to luminance alone (Punzi et al, 2010 *Journal of Vision* **10**(7), 432). Here we measured human visual discrimination of briefly presented sketches (20 ms) containing either color or luminance information or both. Results show that performance obtained with equiluminant sketches (1-bit of color) is significantly lower (chance level) than that with dark/light grey sketches (1-bit of luminance). Adding an extra bit of color to the luminance bit does not increase performance, which is much lower than that obtained with 2-bits of luminance information. This suggests that early visual representations may not use color. Instead, color may be more suitable for a separate level of processing, following a rapid, initial luminance-based analysis.

◆ **Modeling the receptive structure of mid-ganglion cells**

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It is postulated that mid-ganglion cells near fovea receive input from a single (M or L) cone in the receptive field center while having selective or mixed cone opponent input in the surround, although physiological evidence suggests much more selectivity (Lee et al, 2012 *Journal of the Optical Society of America A* **29** 223–232). Beyond 10 deg eccentricity, convergence of mid-ganglion bipolar onto mid-ganglion cells suggests cone selectivity to the center should be lost, and recent measurements (Crook et al, 2011 *Journal of Neuroscience* **31** 1762–1772; Lee et al, 2012 *Journal of the Optical Society of America A* **29** 223–232) support this view. However, ganglion cells at these eccentricities frequently show strong opponency. We report here measurements of receptive field structure using luminance, chromatic and cone isolating gratings, and attempt to model the spatial distribution of cone inputs. Near the fovea, a simple DOG model is often inadequate to describe response profiles. At higher eccentricity, although input to the center may be random, cone selective input to the surround is required to generate the opponency observed. We suggest that, although development of mid-ganglion cell receptive fields may start from random wiring, mechanisms exist to generate opponent receptive fields with approximately equal cone weights, perhaps to compensate for the patchiness of cone distributions in the cone mosaic.

◆ **Colour and luminance inputs into mid- and high-level vision**

B J Jennings, J Martinovic (University of Aberdeen, UK; e-mail: b.jennings@abdn.ac.uk)

In order to create a coherent representation of our visual environment multiple parallel pathways process incoming information, segmenting the image through a series of rapid hierarchically organized stages. We investigated the interdependence of activity within the luminance (L + M) and opponent chromatic (L - M and S - (L + M)) post-receptoral pathways in mid- and high-level vision. Mid-level processes extract contours and perform figure-background organisation, whereas high-level processes depend on additional semantic input such as object knowledge. We collected mid-level (contour/non-contour) and high-level (object/non-object) discrimination threshold data over a range of conditions that isolate pathways or simultaneously stimulate them. Contrast-dependent interactions between the luminance and chromatic pathways were found, with a linear relation of mid and high-level thresholds for luminance inputs. The L - M pathway drove discrimination in the presence of low luminance inputs, but an interaction between the L-M and luminance pathway was observed when the luminance input was higher. When S-cone inputs were relatively high, they slightly facilitated luminance processing. These results are consistent with previous findings on low-level interactions and demonstrate that interdependence between the geniculate pathways extends throughout the visual hierarchy.

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◆ **Heterozygotes for colour vision deficiency reveal themselves in a test of spatial resolution**

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It has been proposed that female carriers of colour vision deficiency have reduced numbers of the type of cones that are lacking in their sons. A new spatial-resolution task was used to estimate the relative number of L- and M-cones in protan and deutan heterozygous carriers and in control women. Acuity was measured in the parafovea where resolution is limited by the sampling density of photoreceptors. A Landolt C target that isolated only one cone type was presented 5° to the left or right from fixation. The contrast was fixed and target diameter was varied. Relative cone numbers were estimated from the ratio of the smallest sizes recognized by M- or L-cones. An ANOVA showed a highly significant effect of phenotype ($F_2 = 9.47$, $p < 0.001$). In addition, there was a strong correlation (Spearman's $r = 0.73$, $p < 0.001$) between these spatial estimates of L:M ratio and estimates from a temporal task using counterphase modulation photometry (the OSCAR test; Estévez et al, 1983 *American Journal of Optometry and Physiological Optics* **60** 892–901). A significant correlation was also found between OSCAR test settings by carriers and by their sons (Spearman's $r = 0.785$, $p < 0.001$), replicating Jordan and Mollon (1997 *Documenta Ophthalmologica Proceedings* **59** 385–392). [Support: RFBR 12–04–01797-a, The Royal Society International Exchanges IE110252.]

◆ **Multiple S-cone signals in BCM and ESCS patients**

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In the presence of a longer-wavelength adapting background, we have reported evidence for a delayed and inverted S-cone signal that shares an achromatic pathway with L- and M-cone signals. Without the background, the S-cone signal disappears, which suggests that it may be an indirect, inhibitory signal that acts only on extant L- and M-cone signals. Here, we measure S-cone temporal-frequency responses in observers with only S-cones (Blue-cone-monochromats or BCM), or with an excess of S-cones (enhanced-S-cone-syndrome patients, or ESCS). Our data suggest the existence of multiple S-cone signals, which we model by supposing that the S-cones interact with L- and M-cones and with each other via a network of lateral connections, and that each connection inverts and delays the S-cone signal. The converging S-cone signals destructively or constructively interfere to produce characteristic patterns in the S-cone frequency response. The data for the BCM observer are consistent with a direct S-cone signal with a substantial lateral connection also from S-cones. The data for the ESCS observers, like those for the normal, are consistent with an indirect S-cone signal acting on L- and M-cones via one or two lateral connections. We suggest that the underlying network is provided by horizontal cells.

TALKS: FACE PROCESSING

◆ **The speed of face recognition: A 50ms gain between personally familiar faces and famous faces**

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Despite the generally accepted notion that humans are very good and fast at recognizing familiar individuals from their faces, the actual speed with which this fundamental brain function can be achieved remains largely unknown. Furthermore, whether this recognition speed is similar for famous faces and personally familiar faces is another unresolved question. A group of 11 participants was required to respond when presented with photographs of personally familiar faces, or, in a separate run, famous faces. The personally familiar faces were extracted from the personal photosets of the participants (440 pictures amongst a total of 23,322 photographs). Matched unknown faces were used as distractors. This go/no-go recognition task performed using speed constraints revealed that personally familiar faces could be recognized as early as 330 ms after presentation, about 50 ms faster than famous faces. Such rapid behavioral recognition constrains how early the effects of familiarity could be observed and demonstrates that personally familiar faces are recognized significantly faster than famous faces. Given the time required to execute a manual response (about 100 ms), the earliest familiarity-dependent

modulation at the electrophysiological level could be expected at about 230 ms after stimulus onset, a value consistent with a number of EEG studies.

◆ **The congruency effect in the composite face paradigm**

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The inability of observers to judge face parts independently suggests that faces are perceived holistically (Tanaka and Farah, 1993). Using the composite face paradigm (CFP; Young, Hellawell, and Hay, 1987) we show that the congruency effect (CE), indicating that nonattended face parts affect the judgments of the attended face parts, is strong (about 20%) when (i) presentation is brief, (ii) no feedback about correctness is provided, and (iii) observers are informed about the target parts shortly before the test image, and are uninformed at study (Conditions A). CEs attenuate down to about 5% at relaxed viewing times, when observers receive feedback about correctness, and when they are informed about the target features right from the beginning of the trial (Conditions B). Moreover, there is strong response bias toward the “different” category for conditions A but not for conditions B. Since no CEs are observed with non-facial stimuli (watches), results indicate that the CE is face specific, but different in nature for conditions of high and low levels of control and feature certainty. For conditions A the CE reflects mostly perceptual (holistic) effects, for conditions B, however, holistic effects are overlaid by effects of selection and control at the decisional level.

◆ **The contributions of external and internal features to face discrimination**

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Face discrimination requires internal (eg eyes) and external (eg head-shape) feature information to be combined. We quantified the contributions of different features for unfamiliar faces. Discrimination thresholds were determined for synthetic face stimuli for the following conditions: (i) ‘full-face’: all face features visible and modified by equal amounts; (ii) ‘individual feature’: all features visible, one feature modified; (iii) ‘isolated feature’: single feature presented in isolation. Features were eyes, nose, mouth, eyebrows, head-shape and hairline. Performance for isolated features was poorer than the full-face condition for all features but head-shape. Average threshold elevations were 0.84, 1.08, 2.12, 3.24, 4.07 and 4.47 for head-shape, hairline, nose, mouth, eyes and brows respectively. Hence, for eyes to be discriminable in isolation, a 4.07x greater change is required than when presented within the full-face. Threshold elevations were higher for the individual feature conditions than for the isolated conditions (0.94, 1.74, 2.67, 2.90, 5.94 and 9.94). Observers are better at discriminating isolated features than when they are embedded in an otherwise fixed face. Similar thresholds for head-shapes and full-faces suggest that observers rely heavily on head-shape when discriminating unfamiliar faces. The pattern of threshold elevations is consistent with lowest sensitivity for features affected by face dynamics eg expression (eyes, eyebrows and mouth).

◆ **Orientation tuning for faces in the Fusiform Face Area and Primary Visual Cortex**

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Face identity processing is tuned to horizontally-oriented cues. Here we used fMRI to investigate the neural correlates of this horizontal-tuning in the Fusiform Face Area (FFA) and V1. Eight subjects viewed blocks of upright, inverted, and phase-scrambled faces filtered to preserve a 20°-orientation range centered either on horizontal, vertical, or oblique orientations. Univariate analysis revealed that the FFA responded most strongly to upright-horizontal faces whereas V1 showed no orientation preference. Linear support vector machines were then used to decode stimulus category (upright, inverted, scrambled) or orientation content (horizontal, vertical, left-oblique, right-oblique) based on FFA and V1 activation patterns. In the FFA, classification of stimulus category was significantly better for upright-horizontal faces than upright-vertical faces. No orientation preference was found for inverted and scrambled faces. In contrast, category decoding was comparable across vertical and horizontal conditions in V1. When decoding orientation, high accuracies were obtained in V1 for upright and inverted faces whereas classification performance was close to chance for scrambled faces. In FFA, orientation decoding was close to chance level in all stimulus categories. These results indicate that (1) FFA is tuned to horizontally-oriented information selectively when processing upright faces and that (2) this horizontal-tuning was not passively inherited from V1.

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◆ **When faced with faces: individual differences in face perception and recognition**

R J Verhallen, G Bargary, J M Bosten, P T Goodbourn, A J Lawrance-Owen, J D Mollon
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Despite the importance of being able to recognise faces, not everybody shows equal performance. To examine this variation between individuals, we tested 395 participants (251 females; mean age 24.2) on four well-established tests of face perception and recognition ability: the Mooney Face task, the Glasgow Face Matching Test (GFMT), the Cambridge Face Memory Test (CFMT), and the Composite Face task. Participants also gave a subjective rating of ability on a scale of 1 to 10, before testing. Results show a broad distribution of performance for all four tests, with scores ranging from 35% to 100% correct. Spearman correlations show a significant positive relationship between subjectively rated ability and performance on each test. Furthermore, performance on each test is significantly correlated with that on every other test. The GFMT and CFMT have the strongest correlation ($\rho = 0.49$) and the Mooney Face task and the Composite Face task the weakest ($\rho = 0.20$). Thus, the shared variance never exceeds 25% and is often much smaller. This could imply that these four tests each primarily measure different aspects of face perception. Our results thereby indicate how multifaceted is the perception and recognition of faces.

◆ **Extensive visual training in adulthood significantly reduces the face inversion effect**

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Human adults are poor at recognizing inverted faces, that is, at recognizing visual stimuli that are as complex as upright faces, yet are neither preferentially attended at birth, nor visually experienced during development. This lower performance for recognizing inverted relative to upright faces constitutes one of the most well known and robust behavioral effects documented in the field of face processing (Rossion, 2008 *Acta Psychologica* **128** 274–289). Here we investigated whether extensive training at individualizing a large set of inverted faces in adulthood could nevertheless modulate the inversion effect for novel faces. Four observers were trained for 2 weeks (16 hours) at individualizing a set of 30 inverted face identities presented under different depth-rotated views. Following training, they all showed a significant reduction of their inversion effect for novel face identities as compared to the magnitude of the effect before training, and to the magnitude of the face inversion effect of a group of untrained participants. These observations indicate for the first time that extensive training in adulthood can lead to a significant reduction of the face inversion effect, suggesting a larger degree of flexibility of the adult face processing system than previously thought.

TALKS: MOTION PROCESSING◆ **Acceleration is detected by comparing initial and final velocities**

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There are many studies of constant velocity motion, but few on the perception of acceleration in the fronto-parallel plane. Logically, acceleration may be detected in two ways: first, it may be processed directly by “acceleration detectors” in the cortex tuned to specific acceleration rates; second, there may be an indirect process whereby acceleration is “inferred” by comparing initial and final velocities. We tested these alternatives by measuring acceleration thresholds while varying absolute acceleration rates within a single presentation. We designed a three-component stimulus in which the initial and final rates were identical, and a middle component that could have a negative, positive, or zero acceleration. We measured acceleration thresholds by varying the initial/final rates using a constant stimuli procedure. If acceleration is detected directly, the initial/final rate should determine thresholds, regardless of the middle rate; if it is detected indirectly, the difference between initial and final velocities, and hence the average acceleration rate across the whole presentation, should be the determining factor. While initial/final rate thresholds changed markedly as the middle rate was varied, these differences were eliminated when the data were replotted as a function of average acceleration. This is strong evidence for an indirect mechanism of acceleration detection.

◆ **Short-term memory for visual coherent motion direction revealed by visual masking**

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Psychophysical research has shown that different attributes of visual stimuli, such as spatial frequency, orientation and speed can be stored in visual short term memory (VSTM) with a high degree of accuracy. Visual memory masking paradigms have been extensively employed to determine which attributes are important in the storage of the information in VSTM. We examined the properties of the storage mechanism for coherent motion. In particular, we presented coherent motion in two distinct temporal intervals, ie, memory and test stimuli (duration: 0.2 s), and introducing random-motion or coherent-motion mask in a 3-s delay. The results ($N=8$) showed that mask mainly interferes with performance when displayed 0.2 s after the offset of the sample and when it was directional rather than random. When using directional masking, we observed a drop in accuracy of ~11% with respect to the no-masking condition. These results suggest that the memory representation of coherent motion is selective for direction, being compromised by intervening directional stimuli presented immediately after the encoding phase (Pasternak and Zaksas, 2003 *Journal of Neurophysiology* **90** 2757–2762), and that the neural mechanisms involved in the processing of coherent motion may also be involved in its storage.

◆ **Perceived motion of moving barber pole arrays is determined by a streaming process**

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We introduce a class of stimuli that demonstrate a new motion perception process. The stimuli are diagonal sinusoidal carrier gratings with bars drifting up to the left, windowed by a raised, vertical, drifting sinusoid. In slow motion, viewed foveally, these stimuli are perceived veridically as arrays of barber poles with blurred edges, the whole array moving laterally (perpendicularly to the orientation of the barber poles) while the stripes inside the poles move up. However, when viewed peripherally, the perceived motion is unambiguously vertical (up or down depending on the direction of motion of stripes within the barber poles) over a wide range of stripe speeds and array speeds. This is surprising because: (1) this stimulus actually moves rigidly in a diagonal direction (feature-tracking direction); (2) the dominant components and vector average of the Fourier components of this stimulus are also diagonal (3) combinations of (1) and (2) are not vertical; (4) second-order motion is shown to be irrelevant. Conclusion: The direction of perceived motion is determined by the orientation of the stream-beds (barber poles) within which pattern motion flows. This streaming process is critically sensitive to stream-bed orientation but remarkably insensitive to the lateral motion of the stream-bed itself.

◆ **Integration of visual-vestibular information for self-motion perception: Role of posterior insular cortex**

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Self-motion perception relies on cues from visual and vestibular senses. Extracellular recordings in the parieto-insular cortex (PIVC; Chen et al 2010 *Journal of Neuroscience* **30** 3022) and the posterior sylvian fissure (VPS; Chen et al 2011 *Journal of Neuroscience* **31** 11617) in primates indicate different roles of these regions in the processing of self-motion cues. Extending our first report (Greenlee et al, 2011 *Perception* **40** ECVF Abstract Supplement, p 26), we analysed the selectivity of these regions in human cortex for visual and vestibular stimulation. Nine participants viewed a large (30 deg) display containing random-dot motion (white dots on dark background). A subset of the dots (10%) moved either to the right or left. During the presentation of coherent motion bithermic caloric irrigation of both ear canals induced a near-threshold sensation of head rotation (yaw) either to the left or right. In a 4-AFC paradigm, participants responded, whether they sensed self motion (in-phase or out-of-phase with visual motion) or object motion (left or right directions). In a control condition, caloric stimulation was applied in the dark (vestibular stimulation only). Here we present the functional analysis of selected ROIs (MST, motion-sensitive STS, PIVC and PIC) that indicated significantly enhanced activation during self-motion in visual-vestibular and vestibular-only conditions. Area MST and STS respond to visual-vestibular stimulation and more to their combination. Area PIVC responds primarily to vestibular, while PIC responds well to visual, vestibular and combined visual-vestibular stimulation. These findings suggest that PIC may be the human homologue of primate VPS, and it supports the integration of visual-vestibular information in self-motion perception. [Support: DAAD-Go8 Exchange Programme.]

Monday

◆ **Disparate persistence of illusory depth and illusory motion in structure-from-motion displays**

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Ambiguous illusory percepts tend to persist even when the display is interrupted and this persistence can be used to probe the specificity of memory representations. We used a structure-from-motion display and dissociated the illusory depth of the interpolated shape from its illusory rotation via the use of a rotationally asymmetric shape (an illusory band) and reversals of physical planar motion. Latter ensured that the prior percept could persist either in terms of illusory rotation or illusory depth of the shape, but not both (Pastukhov, Vonau and Braun, 2012 *Journal of Vision* **12**(1) 17). Observers viewed an ambiguously rotating band and reported on the perceived rotation both before and after interruptions of variable duration. After interruptions of 0.5 seconds or more, the previous illusory motion resumed consistently, demonstrating the superior persistence of the associated memory traces. However, after shorter interruptions, perceptual dominance was determined by the previous illusory depth. This short-lived memory trace is static (showing no sign of dynamical updating) and is specific to the interpolated illusory shape. It is also erased by masking (resembling visual sensory memory). We conclude that disparate visual persistence contributes further evidence for distinct representations of illusory rotation and illusory depth in structure-from-motion displays.

◆ **Motion direction integration following the onset of multistable stimuli (II): stability properties explain dynamic shifts in the dominant perceived direction**

J Rankin¹, A I Meso², G S Masson², O Faugeras¹, P Kornprobst¹ (¹NeuroMathComp Project Team, INRIA Sophia-Antipolis Méditerranée, France; ²CNRS/Aix-Marseille Université, France;
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We use a mathematical model to investigate the early temporal dynamics of motion integration with a multistable input. A drifting grating stimulus is considered with an aperture configuration that supports horizontal (H), diagonal (D) or vertical (V) perceived directions for the same input. A shift in perceptual dominance from D to either H/V with increased presentation duration has been shown in short-presentation psychophysics experiments; see our companion abstract (I). We work with a neural fields, population-level representation of cortical activity that performs motion integration of the competing oblique (D) and cardinal (H/V) local direction signals (Rankin et al, 2011, INRIA Report 7822). When a dynamical system diverges away from a weakly unstable state it can spend an extended transient period close to the unstable state before divergence (Strogatz, 2001 *Nonlinear Dynamics and Chaos*, Perseus, NY). Of the competing states representing the alternative percepts, the initially dominant D is computed to be weakly unstable whilst the subsequently dominant H/V are computed to be stable. The property of weak stability explains the gradual shift in dominance from D to H/V. Moreover, as contrast increases, D becomes strongly unstable reducing the latency of this shift in perceptual dominance.

TUESDAY

TALKS: 3D PERCEPTION II◆ **The herringbone depth effect: the tower of Toulouse**

K Brecher (Boston University, USA; e-mail: brecher@bu.edu)

The effect reported here was first observed after several hundred vision scientists attending the 2011 ECVF reception left the main hall of the Capitolium in Toulouse, France. The floor of the hall is tiled with a wooden herringbone pattern. Without the visual barrier produced by the people filling the hall, the floor immediately took on a “corrugated” appearance. Moreover, a quick photograph taken with a cell phone revealed the “Tower of Toulouse” in which a half dozen of the long herringbone lanes on the floor appeared to “stand up” into a well-defined tower-like structure. A comparable visual effect is elicited by a bent Mach card, which can appear to be either horizontal or vertical when lying on a horizontal surface. The Mach card, however, is an actual three-dimensional structure. In the new effect reported here, the two-dimensional floor gives rise to a very robust three-dimensional “tower”. The herringbone pattern has been used in floor tilings for over two millennia. Pliny the Elder in his “*Naturalis Historia*”—written before 79 AD—described “tile floors with a herringbone pattern”. In the intervening two millennia, there appears to have been no report of this effect in the vision science literature.

◆ **Depicting the visual field in art and science**

R Pepperell (Cardiff School of Art and Design, UK; e-mail: pepperell@ntlworld.com)

This paper will discuss my attempts to depict the visual field in painting and drawing. Depicting visual the visual field means trying to capture natural scenes as they are actually perceived rather than as they might appear in, say, a photograph or computer generated rendering. As I will show, there are a number of fundamental features of visual perception that conventional imaging technology does not record. The most important of these are the differentiation between central and peripheral vision and the relative indeterminacy of objects in the periphery, deformations of objects in space relative to viewing position, and the presence of the viewer’s own body in the field of view. Once these features are accommodated into the depiction, I argue, we arrive at image that is much closer to actual visual perception than images that conform to linear perspective and omit the appearance of the viewer’s own body in the periphery of the visual field. The paper will consider the implications of this approach for the scientific study of perception, how it links to some recent neuroscientific research, and how artists and scientists might benefit from further developing the methods outlined here.

◆ **Distinct correlates of reversing illusory rotation or depth for the structure-from-motion: an MEG study**

A Pastukhov¹, M Bartsch², S Stonkute¹, J Hopf³, J Braun¹ (¹Dept of Cognitive Biology, Otto-von-Guericke Universität, Magdeburg, Germany; ²Leibniz Institute for Neurobiology, Magdeburg, Germany; ³Leibniz Institute for Neurobiology, Magdeburg; Dept of Neurology, Otto-von-Guericke Universität, Magdeburg, Germany; e-mail: pastukhov.alexander@gmail.com)

A cloud of dots in planar motion can induce the compelling illusion of a rotation in depth (“structure-from-motion”). Surprisingly, reversing the planar motion does not necessarily reverse the global illusory rotation. Alternatively, the dots may locally reverse illusory depth, thus allowing the global illusory rotation to continue. This ambiguous outcome is obtained only if the global illusory shape remains unchanged (Pastukhov et al, 2012 *Journal of Vision* 12(1) 17). These psychophysical observations imply that global illusory shape is represented independently of a local illusory depth. Here we use EEG/MEG recording to compare the neural correlates of these alternative perceptual interpretations (reversal of global illusory rotation, GIR, or of local illusory depth, LID) of a physically identical event (reversal of planar motion). Reversals of GIR are associated with phasic activity in a medial-temporal area (presumptive hMT, ~180 ms) and, later, in an immediately adjacent superior region (~270 ms). In contrast, reversals of LID are associated with phasic activity near the intraparietal sulcus (presumptive LIP) and in ventral extrastriate areas (~215 ms). We interpret the latter activity pattern as reflecting renewed “binding” between neural representations of local depth and of global rotation.

Tuesday

◆ **Recovering 3D shape: Roles of absolute and relative disparity, retinal size, and vergence as revealed by reverse-perspective stimuli**

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Purpose: Investigate roles of stimulus size, binocular disparity and vergence under key conditions. Reverspective stimuli were selected because data-driven signals (disparity, motion parallax, etc) help recover veridical 3D shape; they compete against schema-driven influences (experience with perspective, foreshortening, pictorial cues) favoring the illusory depth inversion. The ensuing dynamic depth reversals help study depth perception. Methods: Three scaled-size versions of a reverspective were used. The viewing distance in three conditions was varied while keeping one parameter fixed across the three stimuli: (1) fixed retinal size, (2) fixed disparity, (3) fixed vergence angle. The predominance of the veridical percept was recorded. Results: Unexpectedly, the illusion strength was the same when the vergence was fixed, despite significantly different disparities and retinal sizes; conversely, illusion strength changed significantly in fixed disparity and fixed retinal size conditions. The illusion was stronger for greater distances or, equivalently, for smaller vergence angles. "Relative disparity" (disparity normalized through division by stimulus size) was a good predictor of the data trends. Conclusions: Two possible explanations for the results: (1) Vergence may play a large role in resolving the perceptual conflict between disparity and perspective cues. (2) Disparities may be normalized by stimulus size to recover 3D shape.

◆ **Time in perspective**

A Gorea¹, J Hau² (¹CNRS & Université Paris Descartes, France; ²Université Paris Descartes, France; e-mail: andrei.gorea@parisdescartes.fr)

Perceived size of a constant retinal size object increases as it is displaced toward the vanishing point of a 2D-scene rendered in linear perspective (Ponzo-illusion). The perceived duration (PeDu) of a moving object increases with the trajectory it covers (Kappa-effect; Abbe, 1936). The two phenomena lead to predict that the PeDu taken by moving objects placed in the background of a linear perspective scene will be longer than the PeDu taken by the same objects moving at the same speeds and covering the same angular trajectories in the foreground. Using bicolored 3D-rendered balls rolling in a fronto-parallel plane of a linear perspective 2D-scene (checkerboard), we show that psychological time flows up to 50% faster as the fronto-parallel plane recedes from the observer. Such PeDu dilation was confirmed for 3 physical durations (600, 900, 1200 ms) and 3 trajectory lengths (5.5, 11.0, 22.0 deg). Control experiments show that the phenomenon is contributed to in different proportions by the Ponzo-Kappa combination, the relative balls' sizes, the relative sizes of the background checkers, and the perspective cues (vanishing point) proper. For any of these reasons or for all of them, psychological time expands with the (apparent) distance from the observer.

◆ **From orientation flows to surface inferences**

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One of the most important functions of vision is to estimate the 3D shape of objects in our environment. Many different cues (eg disparities, shading, texture) provide information about shape, but how the visual system estimates shape is poorly understood. It is well understood, however, that the (early) visual system is organized around orientation. Here we present evidence that crucial information is extracted from the way local image orientation signals vary continuously across the surface of an object ('orientation flows'), and that these flows provide the foundation for surface inferences. To start, striking regularities in the flows emerge when computer renderings of shaded and textured objects are represented in a (superficial-layer) V1 fashion. These orientation flows change when illumination and texture patterns change, leading to a number of psychophysical predictions. A model of shape inference from shading flows reveals how surface and light source properties emerge from the flows, and the geometry of the model could be learned by the visual system. Together these findings suggest that the visual estimation of shape from shading, highlights and texture may have more in common than previously thought, and that orientation fields could act as a 'common currency' for the visual estimation of shape.

◆ **Stereomotion scotomas in healthy subjects: stability and cue-dependence**

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The visual field of many people contains regions with decreased or no sensitivity to stereomotion, called stereomotion scotomas (Hong and Regan, 1989). Recently, Rokers et al (2008) revealed two independent binocular cues underlying stereomotion: interocular velocities and changing disparity over time. We hypothesized that stereomotion scotomas are cue-specific. To test our hypothesis, we measured sensitivity to stereomotion across the visual field in 7 subjects. Because the two stereomotion cues have different speed tuning curves (Czuba et al, 2010), we used a stimulus (Gabor, sigma: 0.5deg, lambda: 4cpd) with different monocular speeds to isolate the sensitivity to each cue (changing disparity: 0.25 deg/s—slow, and interocular velocity 2 deg/s—fast). There was a significant difference between the performance in the slower and faster speed condition (mean 66.1% and 79.8% correct, respectively). We found evidence for stereomotion scotomas in both the slow condition (2/7 subjects) and fast condition (3/7), which did not warrant conclusions about the underlying cue. We did reveal that the stereomotion field sensitivities were stable over time within each speed condition (mean correlations 48.1% (slow) and 55.9% (fast)), and furthermore that the stereomotion scotomas could not be explained by a drop off of performance with eccentricity.

◆ **Misperception helps the action—anisotropy of perceived distance and effort**

O Toskovic (Laboratory for experimental psychology, Faculty of Philosophy, Belgrade, Serbia; e-mail: otoskovi@gmail.com)

Distances towards zenith are perceived longer than physically same distances towards horizon. We argued that this kind of perceived distance anisotropy is in a function of action. Namely, if one tends to reach something upwards, opposite to gravity direction, more effort is needed. If visual system overestimates distance, reaching for something further away would demand more effort, and action opposite to gravity direction would be easily done. We tested this hypothesis in two experiments. In a first experiment 15 participants had a task to equalize the distances of two stimuli by hand. Stimuli were on horizontal and vertical direction, on 0.2m, 0.4m and 0.6m distances. Results have shown that participants matched shorter vertical with longer horizontal distances, meaning that they perceived vertical distances as longer. These results show that same anisotropy exists in proprioceptive space as in visual space. In a second experiment 14 participants matched efforts of 2kg, 4kg and 6kg by stretching dynamometer, on horizontal and vertical direction. Results have shown that participants tend to match larger horizontal efforts with smaller vertical, meaning that they perceived vertical efforts as more intensive. Results from both experiments are in line with hypothesis that anisotropy is in a function of action. [Supported by Ministry of education and science, Republic of Serbia, project number 179033.]

TALKS: ATTENTION I

◆ **Effective processing of masked eye-gaze requires volitional control**

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Extant literature indicates that averted eye-gaze cues orient spatial attention. Despite the ease with which gaze-triggered shifts of attention occur, however, there remain important questions about the automaticity of one's response to averted gaze. The aim of the present study is to investigate this aforementioned issue by determining whether shifts of attention to eye-gaze cues can occur when the cues are masked. While we find that unmasked eye-gaze cues are effective in producing a validity effect in a central cueing paradigm, we also find that the efficacy of masked eye-gaze cues is sharply constrained by experimental context. Specifically, masked eye-gaze cues only produced a validity effect when they appeared in the context of predictive unmasked eye-gaze cues. Unmasked eye-gaze cues, in contrast, produced validity effects across a range of experimental contexts, including when 80% of the cues were invalid. These findings demonstrate that, unlike unmasked eye-gaze cues, the effective processing of masked eye-gaze cues is volitional.

◆ **Visual attention: is Posner's beam the same as Treisman's glue?**

R Snowden (Cardiff University, UK; e-mail: snowden@cardiff.ac.uk)

Many experiments show that attending to a particular stimulus enhances the person's abilities to process this stimulus. Two major proposals are that attention enables (1) faster and more accurate detection of the stimulus (Posner's "beam"), (2) features of a stimulus to be combined (Treisman's "glue"). Are these simply two manifestations of the same mechanism? If attention is required to combine features

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(eg. colour and shape), then tasks that require feature combinations should show greater effects of attentional manipulation than those that do not. Using a simple cueing paradigm, we compared the effects of attention on tasks that required either a single feature to be discriminated (colour or shape) with one that required the combination of such features (colour and shape). In separate experiments, we manipulated spatial attention via endogenous or exogenous cues. In both experiments clear effects of cue validity and task were obtained, but there was no interaction between these variables. Similar results were also obtained using a comparison of single lines (feature) versus shape (conjunction). Our results suggest that the guidance of attention (Posner's beam) is not the same as the binding of stimulus features (Treisman's glue) and supports the notion of two distinct processes.

◆ **Emotion potentiates the effect of attention on appearance**

A Barbot, M Carrasco (New York University, USA; e-mail: antoine.barbot@nyu.edu)

Attention enhances apparent contrast (Carrasco, Ling and Read, 2004). Emotional cues potentiate the effect of attention on contrast sensitivity (Phelps, Ling and Carrasco, 2006). Here, we investigated whether emotion modulates the effect of attention on both contrast sensitivity and appearance. In each trial, observers saw two simultaneous gratings (40 ms) at iso-eccentric locations. These stimuli appeared 120 ms (experiment 1) or 580 ms (experiment 2) after the onset of either a peripheral cue adjacent to one location (focal attention) or of two cues adjacent to both locations (distributed attention). The cues were a set of Ekman faces of either neutral or fear expression, upright or inverted (control). Observers were asked to report the orientation of the higher contrast grating. In experiment 1, upright, but not inverted, fearful faces increased the effects of attention on orientation discrimination and enhanced apparent contrast relative to neutral faces. These effects were absent in experiment 2, indicating that the performance and appearance effects are due to the transient nature of exogenous attention. These findings provide strong evidence that emotion interacts with attention at early stages of visual processing. Thus, emotion not only potentiates the effect of attention on performance but also on appearance, altering the way we see. [Support: NIH R01-EY016200.]

◆ **A bias against higher level processing in the learning of individuals with autism: observations in an image feature level visual search task under the interference of object level information**

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Four search stimulus types were interleaved, a letter 'N' target among its mirror reversals (N-search), the mirror reversal target among letter 'N's (RN-search), a tilted X shape (X-search), or its thinner variant target (SX-search), among rotated versions of the X shape. Observers were told that each target was defined by having a uniquely oriented bar (feature) in the image. However, target and non-target object shapes were rotated or reflected versions of each other except in the SX-search. Viewpoint invariant, task irrelevant, shape recognition interferes with the feature detection task, when observers confuse the target and non-targets by their identical shape (Zhaoping and Guyader, 2007 *Current Biology* 17 26–31). Interference (which contrasts X-search from SX-search) mainly causes a prolonged latency to report the target after observer's gaze reaches the target during search. Compared with typically-developed control subjects, high-functioning adults with autism spectrum disorder displayed marginally weaker interference during initial search trials. With more trials, they speeded up their gaze arrival to the target no less than controls but improved significantly less in resisting subsequent interference. We discuss how this learning bias against higher-level processing for top-down control of task strategy may relate to a local processing bias in autism.

◆ **Treating others as intentional agents influences our own perception: An EEG study**

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Directing attention to where others look is the basis for efficient social interaction. Accordingly, other people's gaze direction guides our attention towards potentially relevant locations. With the use of the so-called gaze-cueing paradigm, it has been shown that targets are typically detected, identified, or localized better at locations that were gazed-at by a centrally presented face, relative to other locations (Friesen and Kingstone, 1998 *Psychon Bull Rev* 5 490–495). Our previous findings (Wiese et al, submitted) showed that orienting attention to where others look is modulated by whether people believe that the gazer represents human or nonhuman behavior. In the present study, we used the EEG/ERP method and a gaze-cueing paradigm with human and robot faces to examine whether treating an interaction partner as an intentional agent influences the readiness to engage in social interactions, as measured

by gaze cueing effects. Results showed that the gaze-cueing effects reflected in the P1 ERP component were modulated by the type of the gazer (human or robot). Based on this, we conclude that higher-level social/cognitive processes such as adopting an intentional stance towards an observed agent influence early mechanisms of perceptual selection.

◆ **Stimulus context modulates the speed of visual attention in illusory figure localization**

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In classic visual-search paradigms, processing times to feature singleton targets are typically speeded with decreasing target-distracter similarity. Recently, this well-known and extensively-studied effect has been demonstrated to originate from a pre-attentive processing stage: the coding of stimulus saliency (Töllner et al, 2011 *PLoS ONE* 6(1), e16276). In particular, the conspicuity of target objects was strongly tied to the timing of the posterior-contralateral-negativity (PCN) component, which is triggered based on the outcome of early sensory feature-contrast computations. In everyday life, however, most objects typically remain their identity but the context they are embedded in changes. Thus, this raises the question whether changing the context that surrounds a fixed target identity influences focal-attentional selection times similarly as changing the target identity against a fixed context. To approach this question, we employed a illusory-figure search task which required participants to localize (left versus right) a Kanizsa square, composed of four inward-facing pacman inducers, amongst seven non-target configurations, composed of either one, two, or three inward-facing (together with one outward-facing) pacman elements. Our results revealed PCN latencies being the more delayed the less, relative to more, the target differed from its surround, demonstrating that stimulus context can bias target selection in human visual cortex.

◆ **EEG cross-frequency interaction during an RSVP task**

C Nakatani, C van Leeuwen (KU Leuven, Belgium; e-mail: Cees.vanLeeuwen@ppw.kuleuven.be)

Rapid serial visual presentation (RSVP) is a visual stimulus presentation method in which a train of visual stimuli is presented consecutively in a rapid rate, typically about 10 Hz. Of the train of stimuli, some are targets and others are non-targets. In a typical RSVP task, observers are asked to report the targets. RSVP stimuli evoke oscillations in EEG, of which the frequency is the same as that of the RSVP. We hypothesized that our brain will become entrained to such exogenous activity during practice by increasing the coupling with endogenous EEG oscillations. We recorded EEG while participants were performing an “attentional blink” task, in which they needed to report two targets amongst 17–20 stimuli in 10 Hz RSVP. The 8.0–12.0 Hz band of EEG was considered RSVP-evoked activity. Based on findings from our previous studies, theta-band (4.0–8.0 Hz) EEG was considered as task-relevant, but non RSVP-evoked activity. We computed the amplitude-phase coupling between the 10 Hz amplitude and the theta phase. A strong coupling was observed in parietal, occipital and posterior temporal loci. In accordance with our hypothesis in the occipital and right temporal regions the coupling strength increased between sessions.

◆ **Does visual search have a memory?**

S Bialkova¹, A Nikolaev¹, C van Leeuwen² (¹RIKEN, Japan; ²Katholieke Universiteit Leuven, Belgium; e-mail: sbialkova@yahoo.com)

We tested the memory characteristics of visual search in an event-related potentials study. Participants searched for a target letter presented among nontarget letters. We varied target identity (switch to new vs swap with nontarget from previous trial), nontarget identity (switch to new vs swap with target from previous trial), target location (repeat, switch, swap with nontarget), and nontarget location (repeat, switch, swap with target). Repeated target locations were responded to faster and more accurately than switched ones. There was a slowdown in performance when nontarget and target swapped their locations. The amplitude in the N2pc component was smaller when target location switched than repeated. The amplitude in the N1 component was highest when target and nontarget swapped their roles and target location switched; and smallest when both target and nontarget switched to new identity and target location repeated. These data show that visual search has memory for both target location and identity, but also nontarget identity and location play a role in processing.

Tuesday

TALKS: EYE MOVEMENTS

◆ **Perisaccadic broadening of receptive fields predicts compression of space and time**

G M Cicchini¹, M C Morrone² (¹Institute of Neuroscience, Italy; ²University of Pisa and Scientific Institute Stella Maris, Pisa, Italy; e-mail: concetta@in.cnr.it)

Saccades cause profound transient changes to vision, both to the spatial properties of receptive fields of parietal cortex of macaque monkey and to human perception. In particular, the apparent separation of stimuli are heavily compressed, in both space and in time. Here we modelled saccadic compression and its dynamics by considering that neuronal RF undergoes an enlargement of the spatial and temporal impulsive responses. The front stage of the model is a battery of parallel linear filters whose impulse response broadens (on command from a corollary discharge signal). The crucial stage is a decision/classification of stimulus separation, which measures the spatial-temporal overlap of the neuronal activity (redundancy). In fixation, the model performs as an optimal detector for separation, simulating well Weber's law. Assuming a peri-saccadic receptive-field broadening of a factor of 3, we can model successfully both spatial and temporal compression, simulating well the dynamic for space and time. Remarkably the model also predicts a preservation of Weber's Law for perisaccadic stimuli (Morrone et al, 2005 *Nature Neuroscience* 8(7) 950–954). Overall, this model simulates quantitatively a large battery of psychophysical data (which have proven very resistant to attempts to model them), and also many physiological findings.

◆ **Acoustic modulation of perisaccadic visual detection**

M Panichi¹, F Guidotti², S Baldassi² (¹CNR Institute of Neuroscience, Pisa, Italy; ²University of Florence, Italy; e-mail: michelapanichi@gmail.com)

Around the time of saccades space and time are misperceived. Using psychophysical reverse-correlation, we investigated the perceptual mechanisms subserving visual detection when a brief sound was played at different times relative to saccadic onset and display of the visual target. In a 2AFC task, observers detected the presence of a near-threshold white bar embedded in a 15°x1.5° strip of white dynamic noise briefly flashed either during fixation or immediately after onset of a 15° horizontal saccade. Each trial was either silent (unimodal) or accompanied by a 21 ms sound (bimodal), simultaneous with the visual target, or 43 or 105 ms after it. We computed classification images (CIs) for each condition and found that they depended both on eye position and on temporal separation between visual and acoustic stimuli. The sound increased the amplitude of the CI during fixation only when it was presented simultaneously, whereas during saccades it did so only when it was delayed. The results suggest that cross-modal interaction facilitates perisaccadic detection by providing temporal references to the visual system, thus reducing uncertainty; and they reinforce studies (Binda et al *Journal of Neuroscience*, 2009; Panichi et al *Journal of Vision*, 2012) suggesting that visual processing is delayed during saccades.

◆ **The influence of perceptual grouping by proximity and good continuation on saccadic eye movements**

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Previous research (Ghose, Hermens and Wagemans, VSS, 2012) suggested that saccade latencies can be used as an indirect measure of the strength of perceptual grouping. In these experiments, circles formed by a set of dots embedded in a background of randomly placed dots reduced the time to initiate a saccade to a target when the circle appeared in a location congruent with the target. While these findings suggest a role for perceptual grouping on saccade latency, the stimuli did not distinguish between the effects of grouping by proximity and by good-continuation. Here, we disentangle the effects of the two grouping factors. Fields of oriented Gabor elements were rendered using the GERT toolbox (Demeyer and Machilsen, 2011, BRM). The circles were defined by proximity and by good continuation, or by proximity only (circle elements with random orientations but distance smaller than background), or by good-continuation only (the distance between the properly oriented circle elements was the same as that of the background). We found that grouping by proximity and good-continuation resulted in significant differences in saccade latencies between congruent and incongruent trials but proximity or good-continuation per se failed to show any significant effect in the absence of the other one.

◆ **Scene context and object information interact during the first epoch of scene inspection**

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Are target template and scene context used simultaneously or sequentially during the first epoch of visual search? We manipulated independently the specificity of the template (the picture or the name of the target) and the plausibility of target position in real-world scenes. The availability of a specific visual template facilitated search initiation mainly when the target was in an unexpected location, and a plausible position of the target facilitated search initiation mainly when the template was verbal. Especially with verbal template, participants were more likely to launch the first saccade toward the expected target location when it was occupied by a distractor object than when it was empty. Perceptual salience, evaluated by independent judges, also influenced first saccade direction, and the probability of saccading toward the target was greater when it was of higher salience than the distractor. Our findings show that both target template information and contextual guidance are utilised to guide eye movements from the beginning of scene inspection. They indicate, moreover, that the visual and semantic properties of the object are utilised as sources of local information during the first epoch of visual search.

◆ **Spatiotopic maps take time to construct**

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Many imaging and psychophysical studies suggest that there exist in the human brain spatiotopic neural maps. We investigated the temporal buildup of spatiotopic representation, using two techniques. In both cases, as subjects fixated a point, a target appeared to which they saccaded on cue after variable exposure duration (0, 500 or 1000 ms). We first measured the tilt-aftereffect: subjects adapted to a tilted grating in one part of the screen, then after the saccade judged the orientation of a grating in either the same retinotopic or spatiotopic position as the adapter. For short durations of saccadic target display, the adaptation was primarily retinotopic; but for longer durations (allowing more time to encode position), spatiotopic adaptation increased and retinotopic decreased, saturating at about 1 sec. The second experiment was a variant of "saccadic suppression of displacement" of a target displaced during saccades. Threshold performance improved considerably with exposure duration of saccade target. Both experiments suggest that encoding in spatiotopic coordinates builds up over time, up to one second. The data also account for much of the apparent inconsistencies in the literature about the existence of spatiotopic encoding.

◆ **Optimal integration of afferent and efferent signals in spatial localization**

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As we explore a scene, the visual system can rely on multiple signals to keep track of where objects are in space: the retinal input, a corollary discharge, and extraocular proprioception. Statistically, the optimal strategy to combine multiple estimates is a linear weighted average based on their reliability. Here, we used a novel gaze-contingent display procedure to investigate whether spatial localization in humans conforms to the rules of such an ideal observer. In complete darkness, participants searched for two hidden targets that were briefly displayed at the current gaze position, each one after a predetermined number of saccades. Upon finding the second target, subjects reported the remembered location of the first. As predicted by an ideal observer model, the localization error increased linearly with 1–3 saccades then began to saturate. Extraocular proprioception contributed to 20% of the estimate with just one saccade, increasing to 40% after 3 saccades. Our results show that afferent and efferent signals are optimally combined in the representation of space, thus reconciling a large body of conflicting results in the literature.

TALKS: CROWDING

◆ **Chromatic crowding-effect for cone-isolating stimuli**

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A cone-isolating Landolt C (size 2 deg) was presented 5 deg to the left or right from fixation and was surrounded by four flanking bars isolating also one type of cones. The separation between the test and

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the flanks varied to estimate inhibitory areas. The observers' task was to indicate the orientation of the test. Colour contrast thresholds were measured for each separation between the test and the flanking bars. The inhibitory areas were estimated in two experiments: (a) The test Landolt C was presented to L-cones, the flanks were presented either to L-, or to M-, or to S-cones; (b) The test Landolt C and the flanking bars were presented to the same type of cones. A repeated-measures ANOVA showed that factor 'cone type' was significant in both experiments. The inhibitory areas were defined using post hoc pairwise comparisons with the contrast threshold for the isolated Landolt C. In first experiment the inhibitory areas were significantly smaller when the flanks were addressed to S-cones and increased in the case of the flanks addressed to L- and M-cones. In the second experiment the size of the area is largest in the case of S-cones and the smallest in the case of L-cones. [Support: RFBR grant 12-04-01797-a.]

◆ **When crowding of crowding leads to uncrowding**

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In peripheral crowding, target perception can be strongly deteriorated by nearby flankers. What happens if flanker "A" crowds flanker "B" and "B" crowds target "C"? At 9° eccentricity, we determined offset discrimination thresholds for verniers. When the vernier was embedded in a square, performance deteriorated compared to the unflanked threshold (B crowds C). Interestingly, when adding more squares (flanker A), performance did not deteriorate as expected but strongly improved. Hence, when "A" crowds "B" and "B" crowds "C", "A" un-crowds "C". We propose that this un-crowding effect can be explained in terms of grouping. Grouping between the vernier and the central square leads to crowding. Grouping the central square and the nearby squares leads to grouping of the squares, ungrouping of the vernier, and un-crowding of the vernier.

◆ **Crowding suppresses the N1 wave**

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Flankers can strongly deteriorate performance on a visual target (crowding). For example, vernier offset discrimination is strongly affected by neighboring flankers. Interestingly, performance for longer and shorter flankers is better than performance for equal length flankers. We previously found that crowding is strongest when the vernier and the flankers group (same length flankers) and weaker when they ungroup (shorter or longer flankers). Here, we used high density EEG to investigate the mechanisms underlying crowding. The P1 wave amplitude correlated with the length of flankers (stimulus energy). The N1 wave amplitude correlated with performance, with the highest amplitudes occurring for long flankers, intermediate ones for short flankers, and low amplitudes for medium flankers. The N1 amplitude did not depend on the task difficulty per se but on target-flanker grouping, because increasing vernier offset size did not change the N1 amplitude. We show that the N1 reduction corresponds to suppression in crowding.

◆ **Temporal dynamics of the remote facilitation effect in crowding**

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In peripheral vision, a target letter is harder to identify when it is flanked by nearby letters, an effect called crowding. Here we show that items presented in the fovea that matched a crowded target reduced crowding (the remote facilitation effect), but only when the foveal item was presented within 200 ms of the target. An array of three horizontally arranged letters and numbers, with the target at the center, was presented in the periphery. Additionally, a single number or letter was presented at fixation. Observers indicated whether the target was a number or a letter. To ensure the allocation of attention to both positions, observers also indicated whether the foveal item was the same as the crowded target. The foveal item either matched (Matched condition) or did not match the target (Unmatched condition). We varied the stimulus onset asynchrony between the foveal item and the crowded array. Crowding was reduced in the Matched compared to the Unmatched condition when the foveal item appeared within 200 ms of the target. This limited temporal window for facilitation argues against cognitive biases as a factor in the effect. We suggest that the result is due to long-range grouping processes that precede crowding.

◆ **Perceptual learning enables the brain to overcome the blurred image received from the aging eye**

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In presbyopia (aging eye), the visual input to the brain is limited by the degraded optics of the eye resulting in multiple negative effects on near vision, specifically on reading, near visual acuity (VA), contrast sensitivity (CS), and slower processing speed. We recently showed that perceptual learning (PL) in presbyopia leads to remarkable improvement in VA (81%), CS and contrast discrimination, without changes in optical functions. We adapted our PL method for presbyopia to mobile devices (iPhone, iPad, iPod). The subjects were trained on contrast detection of Gabor targets under backward masking conditions, posing temporal constraints on the visual processing. The training (15 minutes/session, 3 times/week) covered a range of spatial frequencies. The CS on the mobile devices is better by factor of 2.5 than on PC. The improved visual performance enabled the presbyopes to overcome the disabilities imposed by the aging eye. Since PL improved CS and backward masking by decreasing the image processing latency and shortening the reaction time, the improved processing speed of presbyopes may enable recovering a reliable percept from the blurred image received from the aging eye. The results suggest that the aging brain retains enough plasticity to overcome the natural biological deterioration.

◆ **When perceived global shape is different from the sum of its parts**

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Visual coding of shapes is crucial to object recognition and successful interaction within visual environment. Global shape representation depends on integration of local information about curvature (part shape) and its location in object-centered coordinates (part position). Our previous work has shown an important and differential role of contrast polarity in combining smooth parts of object contours compared to those at points of high curvature (Spehar and Clifford, 2002 *Vision Research* 43 1915–1919; Schira and Spehar, 2011 *Frontiers in Psychology: Perception Science* 2 47). Here we report a distortion in the perceived shape of a circle or a square when they are bisected in two halves that differ in either contrast polarity or brightness. When the two differently colored halves are oriented vertically, the perceived shape is vertically elongated, and when the two differently colored parts are oriented horizontally, the perceived shape appears horizontally elongated too. Previous investigations in areas of shape perception and shape illusions have predominantly focused on the role of geometrical factors. Our results demonstrate strong effects of other types of information, known to be important in perceptual segmentation, organization and grouping.

TALKS: ADAPTATION I

◆ **Size adaptation effects are independent of spatial frequency aftereffects**

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Repulsive adaptation effects for spatial frequency, motion and orientation (the tilt aftereffect) are well established, and support the notion of population coding in each of these domains. We have recently proposed (Meese and Baker, 2011 *Journal of Vision* 11(1) 23, 1–23) that the spatial extent of an object or texture is represented in a similar way. If so, adaptation effects should exist that are sensitive to object size (eg diameter) rather than the scale of a texture (spatial frequency). Using a matching task, we measured perceived size of 4 cycles deg⁻¹ gratings before and after exposure to an adaptor that jittered in space to cover the area of the largest target. All eight of our naïve observers experienced a clear shift in perceived size—large targets looked larger and small targets looked smaller. The effect is similar in magnitude (10–20%) to spatial frequency repulsion effects (which we also replicate) but does not induce them: increasing perceived area does not increase perceived bar width. Size adaptation is robust to the relative orientation of adaptor and target, and even occurs for disparate objects such as gratings and faces. This implies adaptation of a broadly-tuned process which estimates the envelope of a stimulus.

◆ **The effect of surface material on colour constancy**

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Unlike matt paper, most materials reflect light differently depending on the angle of the incoming light. We investigated how this may influence human colour constancy. Samples (circular patches, 90 mm) of

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different materials (paper, fur, tile, cloth, leather), were mounted on a sample holder (60 degree slope) and presented in the middle of a black viewing box (1.0 x 1.0 x 0.8 m). Illumination of the scene was provided by a computer controlled, calibrated LCD-projector (Panasonic PT AE 1000E). The observers ($n=4$) viewed the samples frontally (viewing distance 0.90 m), with their heads fixed. All samples appeared achromatic after 2 min adaptation to standard daylight (D65). Colour constancy was quantified by measuring the shift of the achromatic colour locus after adaptation to a new illuminant, picked from one of the cardinal axes in an equiluminant plane in colour space. Measuring the time course (0.2–15 s) of colour constancy for the different materials, we found significant differences at short adaptation times (0.2 s and 0.5 s). In general there was a trend for materials with a higher degree of mesostructure (eg fur) to be better compensated than those with a smoother surface texture (eg tile).

◆ **Statistical context alters perceived similarity: Gabor patches appear much more similar when large patch differences prevail**

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Judgments of stimulus similarity are commonly used to infer underlying sensory representational spaces. Typically, however, stimulus pairs with small rather than large differences occur more frequently, ie possess higher overall base rates. Overall base rates and the stimuli encountered on the initial trials constitute statistical contexts that can alter sensory magnitudes: For example, the perceived speed is lower when fast rather than slow speeds are generally more frequent and/or dominate the series outset (frequency and primacy effects) (Sokolov et al, 2000 *Perception & Psychophysics* **62**(5) 998–1007). Here, we ask if frequency and primacy effects occur with similarity judgments. Four separate groups of healthy adults used a 3-point scale (hardly, moderately, and very similar) to judge pair-wise similarity of six Gabor patches (spatial frequency, 1–10 cycle deg⁻¹ in 0.2 log-steps). Patch pairs with either large or small differences possessed higher overall base rates and/or dominated the initial trials. The results indicate that independently of the content of initial trials, higher base rates of large, compared to small, patch differences yield much higher apparent similarity of the patches (ie the frequency effect). We show for the first time that statistical context modulates similarity judgments, suggesting important implications for computational models of sensory representations.

◆ **Adaptation in visual cortex equalizes population responses**

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Adaptation of neuronal responses in primary visual cortex (V1) has been proposed to discount changes in the statistics of the inputs. To test this hypothesis we recorded neuronal responses in cat V1 using 10 x 10 multielectrode arrays. Stimuli were sequences of gratings flashed for 32 ms. In control experiments all orientations had the same probability of occurrence (4–9%). In adaptation experiments one orientation (the adaptor) occurred with a higher probability (30–50%). Following adaptation, neurons selective for the adaptor gave similar average firing rates as the others despite being stimulated 3–7 times more often. Adaptation, therefore, maintains a flat probability of firing across the population. We described responses using a linear-nonlinear model. The linear filters are defined in stimulus orientation (tuning curves) and time. The model captured the data during both control and adaptation experiments with the same nonlinearity. Hence, the effects of adaptation are entirely captured by the linear filters. We conclude that adaptation is a homeostatic mechanism that maintains a flat distribution of responses in the face of biases in the ensemble of stimuli. It changes responsiveness by exactly the right amount, and exactly in the right neurons, to discount changes in the average firing of subpopulations. [Supported by European Research Council and Medical Research Council.]

◆ **Extreme motion aftereffects**

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Motion aftereffects are either slow as compared to the inducing motion, or fast when their speed is imposed by the spatiotemporal features of a counterphase flicker. Here we show that when motion adaptation effects are induced by brief transients, they can be extremely fast, resulting in perceived motion that can be many tens of times faster than the inducer (and without the speed being imposed

by counterphase flicker). As with regular motion adaptation, these effects are in the same direction as the inducing motion for brief adaptation, and in the opposite direction for longer adaptation. The jumps perceived are extreme, in that their amplitude, which varies from observer to observer, is at or just beyond each observer's maximal veridically perceived motion limit. These results are compatible with a process in which motions up to d_{max} are excluded, and with the minimal motion principle placing the perceived motion just beyond this excluded range.

◆ **Inferences of material properties based on frequency-band analyses**

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Successful functioning in the world often requires rapid and accurate assessment of material properties. We show that real materials exhibit characteristic configurations of low-level features, and the perception of properties like roughness, thickness, volume, can be altered by increasing or decreasing the relative energy in specific spatial-frequency bands of the image amplitude spectrum. These results suggest that simple neural "detectors" for material properties could just combine the outputs of sets of frequency-selective V1 neurons. Can such detectors be revealed through selective adaptation? We modified images of fabrics by increasing or decreasing relative energy in the specific frequency-bands identified by our image analyses (constant total energy). Baseline psychometric functions for each property were measured by side-by-side comparison of the original image with its manipulated versions. During the adaptation stage, dynamic white noise stimuli in specific frequency-bands were presented on the location of the original image, and the complementary notch-filtered dynamic noise presented on the location of the comparison image. Post-adaptation psychometric curves revealed that depending on adaptation frequency-band, observers judged fabrics as having systematically less surface volume, softer texture, or thinner weave/knit, as predicted. Consequently the visibility of specific frequency bands is directly linked to the perception of corresponding material properties.

TALKS: CLINICAL VISION

◆ **Two colour blind simulation tools evaluated using simulcheck**

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Three colour vision alteration simulation tools, belonging to two different types (optical simulation, Variantor goggles. Software simulation, vischeck and coblis) were evaluated using simulcheck. Real and simulated dichromats participated in the evaluation. On the one hand, real dichromats responded to original stimuli and, on the other, normal observers responded to stimuli transformed by the evaluated simulator. It was assumed that the less difference between the results provided, the better a simulator was. The first part of simulcheck (pseudo-achromatic selection task) required real (5 protanopes and 5 deuteranopes) and simulated (10 normal trichromats) dichromats to select the least chromatic stimulus from a colour set where the chromatic angle (H^*) was systematically changed (9° between adjacent stimuli) to cover the full colour circle. The second part of simulcheck (lightness matching task) was the application of a spatial version of the AMLA method used to measure the luminance factor (Y/Y_n) of the stimuli selected in the first part. There were important differences between the simulation tools accuracy. Vischeck provided the best results (only a minor significant difference appeared when simulated dichromats were compared with real ones). On the other hand Coblis produced important errors for both simulcheck tasks and dichromat types. The most important ones appeared for protanopes and the simulated pseudoachromatic red (luminance-lightness very much over the one perceived by real protanopes). Variantor goggles shows and intermediate accuracy level. The main limitation of Variantor derives of not doing different simulations for protanopes and deuteranopes. The practical implications of these results are discussed within the universal design framework.

◆ **Number sense in autism**

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Number skills are often reported anecdotally and in the mass media as a relative strength for individuals with autism. The handful of studies on mathematical achievement nevertheless demonstrates that while some children with autism show talents in this area, a substantial proportion of children struggle with this aspect of the school curriculum. This study therefore sought to examine whether children with autism,

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like typical children, possess an intuitive feel for numbers—a “number sense”—and whether variation in their mathematical skills can be explained by strengths and weaknesses in this sense. 24 cognitively able children with autism (range = 8–12 years) and 24 typical children of similar age and ability were administered a standardized test of mathematical achievement and two experimental estimation tasks, one psychophysical non-symbolic estimation task and one symbolic estimation (number-line) task. Children with autism showed difficulties only on the number-line task, which required matching spatial quantities with a numerical value. Furthermore, individual differences in performance on the number-line task were significantly correlated with autistic children’s academic achievement, such that better number sense skills went hand-in-hand with better arithmetic skills. These findings question the widespread belief that mathematical skills are generally enhanced in autism.

◆ **Perception of numerosity, time and attention in preterm children of low birth-weight**

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Attention, perception of time and numerosity are high cognitive functions important for everyday life. Children born long before term show a high incidence of learning disorders, especially in mathematics. In this study we measured performance of school-aged children born pre-term (gestational age less than 32 weeks, $N=20$, no apparent brain lesions) and age-matched controls on several tasks: (1) numerosity discrimination; (2) visual, auditory and audio-visual time bisection; (3) mapping number onto space; (4) sustained visual attention (multiple object tracking); (5) contrast sensitivity for stationary and moving gratings. The preterm group showed significant impairments in all tasks except contrast sensitivity, and the degree of deficit correlated strongly with gestational age and with birth weight. The results suggest that the deficits may be specific to high-level visual functions probably mediated by parietal cortex.

◆ **Functional modulation of object-selective areas in stroke patients with ventral cortical lesions**

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Specific cortical areas, such as lateral occipital complex (LOC), fusiform face area (FFA) and parahippocampal place area (PPA), are engaged in processing of complex visual scenes. We used functional magnetic resonance imaging (fMRI) to investigate how these areas are functionally modulated in stroke patients with unilateral ventral cortical lesions. Patients performed an object categorization task, with images presented to the left or right of a fixation point. LOC, FFA and PPA were defined in a separate mapping session. BOLD responses were normal in LOC, while activity in FFA was down-regulated bilaterally in patients compared to healthy controls, suggesting impairments of both, the damaged and the intact hemisphere. Usually, activity is higher for contralaterally than for ipsilaterally presented stimuli (contralateral bias). Both, FFA and PPA of the lesioned hemisphere lacked the contralateral bias, indicating disturbed object processing in the lesioned hemisphere. These results correspond to our behavioral data, since patients made more errors and reacted slower when stimuli were presented in the contralesional visual hemifield. In summary, the functional modulation of the ventral object network is disturbed after focal brain lesions. This is reflected by impaired performance and altered activity pattern in cortical object areas, suggesting incomplete reorganization processes.

◆ **Retinotopic maps in human visual cortex following hemispherectomy at age 3**

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Human visual cortex contains maps of the visual field. Much research has been dedicated to answering whether and when these visual field maps change when critical components of the visual circuitry are damaged. Here, we present the case of a sixteen-year-old patient who lost the entire left cerebral hemisphere at age of three. Using a functional magnetic resonance imaging (fMRI) retinotopic mapping procedure and population receptive field modeling, we found that (1) despite the long period since the hemispherectomy, the retinotopic organization of early visual cortex remained unaffected by the removal of an entire cerebral hemisphere, and (2) the intact lateral occipital cortex contained an exceptionally large representation of the center of the visual field. The same method also indicates that the neuronal receptive fields in these lateral occipital regions are extraordinarily small. While these features are

clearly abnormal, we argue that they do not necessarily stem from cortical reorganization: they can also be explained by the notion that the hemispherectomy took place during a critical period and arrested its normal development. Studying visual field maps under atypical conditions such as presented here, may therefore be a very fruitful way to understanding normal development.

◆ **Consequences of chiasmatic abnormalities on the organisation of the ventral processing stream**

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Purpose: Due to an abnormal projection of the temporal retina to the contralateral and ipsilateral hemisphere in albinism and achiasma, respectively, the visual cortex receives additional input from the ipsilateral visual hemifield. Consequences of these misprojections on visual function are surprisingly small. Methods: We scanned 5 albinotic, 1 achiasmic, and 5 human control subjects with optimised retinotopic mapping procedures at 7 or 3 Tesla to detail the organization of early and higher visual cortex (voxel size: 2.53 mm³; TR: 2.4 s; volumes per scan: 105). Results: The ipsilateral visual field was represented as a retinotopic map, in albinism contralateral and in achiasma ipsilateral to the stimulated eye. This abnormal representation was mirror-symmetrically superimposed onto the normal representation of the contralateral visual field, not only in early, but also higher visual areas of the ventral processing stream (V4, VO1/2, PHC1/2). Conclusion: The observed organisation of large parts of the visual cortex highlights conservative geniculo-striate and cortico-cortical projection patterns, which result in extensive abnormal cortical visual field representations. We conclude that, in both albinism and achiasmia, these are made available for visual perception by subtle changes of the intracortical architecture. [Supported by DFG (HO 2002/10-1), and the federal state of Saxony-Anhalt (CBBS).]

TALKS: BIOLOGICAL MOTION

◆ **Dynamics of walking adaptation aftereffects induced in static images of walking actors**

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Visual adaptation to walking actions results in subsequent aftereffects that bias perception of static images of walkers in different postures so that they are interpreted as walking in the opposite direction to the adapting actor. In order to test how walking aftereffects are comparable to other well studied low- and high-level visual aftereffects we measured walking aftereffect dynamics in order to assess the characteristics of the adapting mechanism. We found that walking aftereffects showed similar characteristic dynamics as for face aftereffects and some motion aftereffects. Walking aftereffects could be induced in a broad range of different static images of walking actors and were not restricted to images of actors in any particular posture. Walking aftereffects increased with adapting stimulus repetition and declined over time. The duration of the aftereffect was dependent upon time spent observing the adapting stimulus and could be well modelled by a power-law function that characterises this relationship in both face and motion aftereffects. Increasing the speed of the adapting stimulus by increasing actor walk speed increased aftereffect magnitude, as seen for some motion aftereffects. The nature of the aftereffects induced by observing walking actors indicates that they behave like traditional high-level visual aftereffects.

◆ **Emotion through point-light human locomotion: gender effects**

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Body language reading is of importance for daily-life social cognition and successful social interaction. Yet it is unclear whether our ability for body language reading is gender dependent. In the present work, healthy female and male observers had to recognize emotions through point-light human locomotion performed by female and male actors with different emotional expressions (happy, angry, or neutral). For subtle emotional expressions, males surpass females in recognition of happy walking portrayed

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by female actors, whereas females tend to excel in recognition of hostile angry locomotion expressed by male actors. In contrast to widespread beliefs about female superiority in social cognition, the findings suggest that gender effects in recognition of emotions from human locomotion are modulated by emotional content of actions and (opposite) actor gender. The outcome is discussed in the light of recent work on gender effects in emotion recognition from point-light body motion (Alaerts et al, 2011 *PLoS ONE* 6(6) e20989; Sokolov et al, 2011 *Frontiers in Psychology* 216). Overall, the study takes a further step in clarification of gender-related impairments in body language reading (Pavlova, 2012 *Cerebral Cortex* 22(5) 981–995).

◆ **Structural connection between the cerebellum and temporal cortex underpinning biological motion processing**

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Previous work in lesional patients suggests engagement of the left lateral cerebellum in visual processing of body motion (Sokolov et al, 2010 *Cerebral Cortex* 20(2) 486–491). Cerebellar involvement in the network dedicated to body motion processing appears to be mediated through two-way effective connectivity with the right superior temporal sulcus (STS) (Sokolov et al, 2012 *NeuroImage* 59(3) 2824–2830). Yet the underlying pattern of structural connectivity between the STS and cerebellum remains unknown. Here we address this issue by combining diffusion tensor imaging (DTI) with functional magnetic resonance imaging (fMRI). Participants viewed point-light biological motion and spatially scrambled displays while performing a one-back repetition task. Probabilistic tractography on individual seeds in the STS and left lateral cerebellum resulting from fMRI analysis revealed two structural connections forming a cerebello-temporal loop. The findings point to a structural pathway presumably underpinning communication between the STS and cerebellum during visual biological motion processing. This connection might also be of potential significance for other visual social functions.

◆ **Increased eccentricity reduces the contribution of form to the perception of biological motion**

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The perception of biological motion relies on the integration of form and motion cues, although assessing the contribution of each cue is difficult. We hypothesized that the contribution of form to perception of the facing direction of a point-light walker (PLW) would decrease as eccentricity increased at a faster rate than the contribution of motion. To test this, participants ($n = 14$) reported the facing direction of a PLW that was walking forwards (FW) or backwards (BW). While form and motion can both be used for facing direction for FW, motion is incongruent with facing direction for BW, and accurate discrimination relies on form. PLWs were presented in random noise (65 dots), with a height subtending 7deg, at fixation and at 2, 4, 6, 8, and 10 deg eccentricity. We found that eccentricity had a significantly greater effect on accuracy for BW than FW, especially for eccentricities of 2–4 deg. These results suggest that increasing eccentricity has a greater effect on the contribution of form cues to the perception of biological motion than on the contribution of motion cues. This is consistent with the suggestion that the relative contribution of form and motion cues to biological motion perception depends on each cue's reliability.

◆ **How are facial expressions represented in the human brain?**

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The dynamic facial expressions that we encounter every day can carry a myriad of social signals. What are the neural mechanisms allowing us to decode these signals? A useful basis for this decoding could be representations in which the facial expressions are set in relation to each other. Here, we compared the behavioral and neural representations of 12 facial expressions presented as pictures and videos. Behavioral representations of these expressions were computed based on the results of a semantic differential task. Neural representations of these expressions were obtained by multivariate pattern analysis of functional magnetic imaging data. The two kinds of representations were compared using correlations. For expression videos, the results show a significant correlation between the behavioral and neural representations in the superior temporal sulcus (STS), the fusiform face area, the occipital

face area and the amygdala, all in the left hemisphere. For expression pictures, a significant correlation was found only in the left STS. These results suggest that of all tested regions, the left STS contains the neural representation of facial expressions that is closest to their behavioral representation. This confirms the predominant role of STS in coding changeable aspects of faces, which includes expressions.

◆ **Coherent form, motion and biological motion perception in congenital achromatopsia**

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In congenital achromatopsia there is an absence of functioning cone photoreceptors, so that from birth vision is entirely reliant on rods. The impact of this on extrastriate visual functions such as coherent form and motion perception has not previously been explored. In healthy controls, rod-mediated perception as assessed under scotopic conditions showed normal coherent motion thresholds, but increased form-from-motion and biological motion thresholds (Gegenfurtner et al, 2000 *Journal of the Optical Society of America A* **17**(9), 1505–1515; Grossman and Blake, 1999 *Vision Research* **39**(22), 3721–3727). We measured coherence thresholds using 2AFC for circular form, rotating motion and biological motion in achromats ($n=3$) and controls ($n=5$) under scotopic and mesopic conditions. In both groups, form and biological motion thresholds increased scotopically, while motion remained stable. At both light levels, thresholds for form and motion, but not biological motion, were higher in achromats than in controls. The results indicate that congenital absence of functioning cones leads to deficits in coherent form and motion perception even at scotopic light levels. This implies that cone pathways play a role in development of rod-mediated extra-striate processing. Achromats' increased thresholds under scotopic vs mesopic conditions suggest differential involvement of visual pathways (eg fast vs slow rod pathway) in the two conditions.

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TALKS: ATTENTION II

◆ **Accentuation-suppression and scaling: arousal modulation of attentional processing**

T A Sørensen¹, C Bundesen² (¹Aalborg University, Denmark; ²University of Copenhagen, Denmark; e-mail: alrik@hum.aau.dk)

The limitations of the visual short-term memory (VSTM) system have become an increasingly popular field of study. One line of inquiry has focused on the way attention selects objects for encoding into VSTM. Using the framework of the Theory of Visual Attention (TVA; Bundesen, 1990 *Psychological Review* 97 523–547) different components of attention were measured while arousal was systematically varied by manipulating temporal expectancies of the observer. The results showed increments in both overall speed of encoding into VSTM and efficiency of visual selection as the level of arousal was increased, whereas VSTM capacity showed some decrease with increasing arousal. Furthermore, attentional weights seemed to be modulated such that, as arousal increased, the attentional focus narrowed around fewer, highly relevant objects. Arousal seems to interact with attention in two different ways: Through a scaling mechanism modulating the decision bias of the observer and also through an accentuation-suppression mechanism that modulates the degree of subjective relevance of objects, contracting attention around fewer, highly relevant objects while suppressing less relevant objects. These mechanisms may afford an evolutionary advantage for an observer, ensuring that the most relevant objects are selected and encoded faster under high arousal, and making later processing more focused as the capacity of VSTM is decreased.

◆ **Attention allocation to regions perceived as holes**

M Bertamini, M S Helmy (University of Liverpool, UK; e-mail: maisalah@liverpool.ac.uk)

The reversal of figure-ground assignment for a closed region is the purest form of figure-ground organisation, and the two resulting percepts are that of an object and that of a hole. Both are non-accidental regions and can share an identical outline. In one series of experiments observers judged the shape of a contour that could be either the same or different from an irrelevant surrounding contour. We report that different (incongruent) inside and outside contours produce stronger interference when they form a single object-with-hole, compared to a hierarchical set of surfaces, or a single hole separating different surfaces (a trench). Therefore which surface owns the contour constrains the interference between shapes, and regions perceived as holes do not display object-like properties. In another series of experiments we used a probe presented near the contour, and we compared the speed of responses to probes presented near corners or along the straight edge. We replicated the corner enhancement effect (Cole et al 2001 *Journal of Experimental Psychology: Human Perception and Performance* 27 1356–1368) but only when the probe was perceived as located on the surface that owned the corner, thus even in this case holes did produce very different results compared to the same region perceived as an object.

◆ **The role of parietal cortex in updating changing visual representations**

C Howard¹, N Bashir², G Humphreys³ (¹Nottingham Trent University, UK; ²University of Birmingham, UK; ³University of Oxford, UK; e-mail: Christina.Howard@ntu.ac.uk)

The dynamic nature of the world requires us to keep our visual representations up to date. Representations are more precise if they use a narrow time window over which information is sampled and averaged. Limited temporal precision can cause percepts of changing objects to lag by up to 250 ms in the past (Howard and Holcombe, 2008 *Vision Research* 48 1164–1180). The parietal lobe is involved in spatial vision, and has been implicated in temporal aspects of perception, such as onset-offset discrimination, apparent motion and temporal order judgments. However, the role of the parietal lobe in temporal precision of perception is still unresolved. We tested patients with parietal lobe damage on a continuous monitoring task. Patients attempted to keep track of the changing spatial frequency of a luminance grating. After a few seconds, the grating disappeared and patients reported its final spatial frequency. By comparing the reported value and the actual feature values over the last frames of the stimulus, patients' perceptual lags were calculated. We find longer and more erratic perceptual lags in patients with parietal damage than in healthy adults. Performance remained poor for some patients even with slow 2.5 Hz change rates. We discuss the role of parietal cortex in spatio-temporal processing.

◆ **Visual illusions of size influence throwing performance in darts**

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Baseball players who hit the ball more often judge the ball to be bigger than their less successful counterparts (Witt and Proffitt, 2005 *Psychological Science* **16** 937–938). This phenomenon is dubbed action-specific perception. The processes underlying action-specific effects are largely unknown. To further specify the constraints under which performance-related alterations in perception occur, we conducted two experiments in which participants performed a dart throwing task towards a circle-shaped target. The target was either presented in isolation or surrounded by smaller or larger circles, inducing the well-known Ebbinghaus size illusion. In line with our predictions, results revealed that participants who perceived the target as being bigger (than it physically was) hit the target significantly more often than those who perceived it as being smaller. However, the typically reported correlation between perception and performance was absent. While the findings thus provide strong evidence that visual illusions influence target-related performance, they do not support an action-specific perception account.

◆ **Temporal integration in rapid serial visual presentation**

E Akyurek (University of Groningen, Netherlands; e-mail: egakyurek@rug.nl)

Visual temporal integration is a perceptual process that combines successive sensory input across brief intervals, thereby merging it into a single coherent percept. It has been suspected that temporal integration might play a role in two-target rapid serial visual presentation (RSVP) tasks, particularly when the targets follow each other directly, that is, at Lag 1. To date, evidence for this idea has come from the analysis of report order errors, but these could not conclusively demonstrate that other mechanisms (such as prior entry) might not instead underlie performance at Lag 1. Using a novel design, in which the targets could be combined perceptually in a meaningful way such that the conjunction of the two target elements constituted a possible target stimulus itself, it was shown that observers indeed frequently reported the integrated percept. These reports were robust across a range of different visual targets. Further experiments tested the extent to which temporal integration might play a role across larger intervals and multiple successive targets. The results demonstrated that temporal integration of target-related information can occur across a relatively wide temporal range, and multiple successive stimuli, suggesting that temporal integration may play an important role not only in short intervals, but also in the construction of longer (attentional) event episodes.

◆ **Linking perceptual animacy to attention: Chasing detection among visually indistinguishable distractors**

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Perceptual animacy describes the tendency of human observers to interpret spatio-temporal contingencies in motions of simple shapes in anthropomorphic terms such as social causation or intention. Typically, perceptual animacy has been studied isolated from other psychological concepts such as attention. Recent studies established a chasing detection paradigm that allowed to study animacy psychophysically. This line of research has argued that a chase is perceived efficiently among distractors. Here, we present several variants of the chasing detection paradigm to investigate the link between perceptual animacy and attention. In experiments 1a and 1b, we show that detection accuracy and response latency depend on the physical set size, suggesting that chasing detection is inefficient. Experiment 2 replicates these findings with an attentional set size manipulation. Finally, experiment 3 combines the chasing detection task with an attentional cueing paradigm to directly guide attention. Valid cues enhanced chasing detection indicating that chasing detection requires effortful visual search through subsets of all possible items. Overall, our results suggest that human observers can visually search for a pair of chasing objects among otherwise indistinguishable distractors. However, there is no pop-out effect for chasing stimuli. Thus, attention plays a crucial role in chasing detection.

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◆ **Automatic correspondence by surface features during visual tracking across spatiotemporal discontinuities**

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Observers can track multiple moving objects among indistinguishable distractors. Previous research focused on the role of spatiotemporal features for tracking. In three experiments, we studied the role of surface features of tracked objects for establishing object correspondence during visual tracking. We presented three-dimensional scenes with balls moving on a floor plane. These balls were colored briefly before and after a spatiotemporal discontinuity (ie, an abrupt scene rotation). Distinct colors matching the spatiotemporal information across the discontinuity caused higher tracking performance than homogeneous coloring. In contrast, swapping distinct colors during the discontinuity impaired performance. In the swap condition, participants mis-selected more distractors appearing in a former target color than distractors appearing in a former distractor color. Even when color never supported tracking in any trial and when we instructed participants to ignore color, we observed the tendency to select distractors in former target colors. This shows that surface features are encoded and utilized automatically during tracking. Introducing abrupt scene rotations disrupts the spatial configuration in the picture plane. This is no precondition for automatic color correspondence, which we replicated in a further experiment with abrupt zooms retaining the spatial configuration. We conclude that the tracking mechanism utilizes spatiotemporal and surface features.

◆ **TAM2: a theory of eye movements during categorical visual search**

G Zelinsky (Stony Brook University, USA; e-mail: Gregory.Zelinsky@stonybrook.edu)

Categorical search, the task of finding and recognizing categorically defined targets, has long been neglected by search theory. Recently, we compared several computer vision models and found that one combining C2 features with color described categorical search guidance and recognition exceptionally well for a complex class of objects (VSS 2012). The present work integrates this feature with TAM, enabling the modeling of eye movements to categorical targets. TAM2 uses distance from an SVM classification boundary to obtain a probability map indicating evidence for the target category at each scene location. We tested TAM2 in 3 experiments: (1) a variable set size (6/13/20) present/absent search task using teddy bear targets and random category distractors, (2) a search task in which distractors had high, medium, or low visual similarity to the target category, and (3) a task identical to (1) using butterfly targets instead of bears to test generalizability. In each task TAM2 successfully described the guidance of gaze to categorical targets. Importantly, TAM2 supplements rather than supplants TAM; if a target preview is available and categorical search is unnecessary, TAM2 reverts back to TAM. It is only when target appearance is uncertain that TAM2 uses categorical target features retrieved from LTM to drive its search.

TALKS: ADAPTATION II

◆ **Long-term recalibration of orientation perception**

P Mamassian, A Chopin (CNRS, Université Paris Descartes, France; e-mail: pascal.mamassian@parisdescartes.fr)

In the tilt after-effect, adaptation to left-oriented bars leads to an illusory right tilt of a perfectly vertical bar. This result is often taken as evidence that the visual system recalibrates its expectations for vertical with stimuli presented during the adaptation period. We wondered whether expectations take their origin in some kind of ideal norm or instead are inferred from the environment. Observers were presented with series of Gabors that could have one of two orientations A and B separated by 40 degrees. A test Gabor was subsequently presented and observers had to judge whether its orientation was closer to A or B. Unbeknownst to the observer, the orientation of the test was always exactly in-between A and B. We found that the perceived orientation of the test Gabor was biased away from the orientations of recently presented stimuli (tilt after-effect) and more surprisingly, toward the orientations of stimuli presented further in the past. We propose that the remote past is used to estimate the world's statistics and that this estimate becomes the reference. More specifically, orientation perception is recalibrated relative to remote percepts (up to 10 min in the past) rather than relative to an ideal norm.

◆ **Testing the channel-based model of duration perception**

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The channel-based model of duration perception postulates the existence of neural mechanisms that respond selectively to a narrow range of stimulus durations centred on their preferred duration (Heron et al *Proceedings of the Royal Society B* **279** 690–698). In principle the channel-based model could explain recent reports of adaptation-induced, visual duration compression effects (Johnston et al *Current Biology* **16** 472–479; Curran and Benton *Cognition* **122** 252–257); from this perspective duration compression is a consequence of the adapting stimuli being presented for a longer duration than the test stimuli. In the current experiment observers adapted to a sequence of moving random dot patterns at the same retinal position, each 340ms in duration and separated by a variable (500–1000ms) interval. Following adaptation observers judged the duration of a 600ms test stimulus at the same location. The test stimulus moved in the same, or opposite, direction as the adaptor. Contrary to the channel-based model's prediction, test stimulus duration appeared compressed, rather than expanded, when it moved in the same direction as the adaptor. That test stimulus duration was not distorted when moving in the opposite direction further suggests that visual timing mechanisms are influenced by additional neural processing associated with the stimulus being timed.

◆ **Orientation tuning and normalisation in the tilt aftereffect**

P Thompson, E Gross (University of York, UK; e-mail: pt2@york.ac.uk)

The tilt aftereffect (TAE) is usually demonstrated by adapting to a grating tilted approximately 10 degrees from vertical, after which a vertical grating appears tilted in the opposite direction. During adaptation the perceived orientation of the adaptor shifts towards the 'null' vertical position. This has been called normalisation. The spatial frequency aftereffect (SFAE), often attributed to the same neural processes as the TAE, behaves in a very different fashion, with no null point and hence no normalisation. We have investigated the effects of tilt adaptation to 0 deg (vertical), 15 deg and 45 deg gratings on a range of test gratings from -90 to 90 deg in 15 deg steps, using an orientation matching procedure. Our results show that adaptation to 45 deg (and to a lesser extent 0 deg) produces aftereffects similar to those of the SFAE, with shifts in perceived tilt away from the adaptation orientation, and no normalisation—the signature of adaptation of multiple narrowly tuned channels. Adaptation to 15 deg produces an effect that suggests both strong normalisation towards vertical and evidence of multiple orientation channels. These results suggest that normalisation and channel adaptation may be thought of as separate and distinct processes.

◆ **Temporal frequency tuning of the cortical face-sensitive network for individual face perception**

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In the present study we investigated the temporal frequency tuning of face-sensitive areas with functional magnetic resonance imaging (fMRI). Six observers were tested in an adaptation paradigm where blocks of same or different faces were presented at 11 different frequencies (1, 2, 3, 4, 5, 6, 6.66, 7.5, 8.57, 10, 12 Hz). The right fusiform face area and right occipital face area showed an adaptation effect—difference between same and different faces—consistently peaking, on average, at 6Hz. This effect was due both to the quick drop of the signal during the transition from 4 to 6Hz in the same condition and to a larger response for different faces (different condition) which decreased for frequencies higher than 6Hz. Therefore individual face discrimination seems to be optimal when a face is presented at a rate of 6Hz. Interestingly, at this rate, the complete cycle of the sinusoidal stimulation of a face lasts about 170 ms which is also the latency of the earliest face identity adaptation effect as found on the face-sensitive N170 ERP component (Jacques et al, 2007 *Journal of Vision*). Our results support the view that the human brain requires about 160 ms to process individual faces efficiently.

◆ **Global shape processing involves feature selective and feature agnostic coding mechanisms**

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Recent research and modelling proposes that a shape is accurately described by both the degree of curvature and the angular location (relative to shape-centre) of its curved parts; a shape orientation selective representation. We tested this proposition. Radial Frequency (RF) patterns were employed as stimuli since these can represent a range of familiar shapes, and are processed globally. We measured

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an RF amplitude after-effect (AE) as a function of the shape orientation difference between adapt and test patterns, of the same RF. For RF3 and RF4, AEs were largest when adapt and test patterns were the same orientation, and then linearly decreased as the adaptor was rotated away. Interestingly, AEs did not reduce to zero, instead plateauing significantly above zero. By contrast, when adapt and test were opposite luminance-polarity, AEs were reduced and orientation invariant. When opposite luminance-polarity AEs were subtracted from same luminance-polarity AEs, a difference emerged only for similar adapt and tests orientations; thus ruling out local orientation adaptation as an explanation for this sub-set of the AEs. Our findings provide evidence for two global shape mechanisms: one that is selective for shape orientation and luminance polarity, and one that is agnostic to these characteristics.

◆ **Stimulus probability and stimulus expectation affect the activity of face and house selective areas of the human brain independently**

G Kovács, M Grotheer, M W Greenlee (Institute of Psychology, Germany;
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It has been shown that the probability of face repetitions influences the magnitude of repetition-related response reductions (Summerfield et al, 2008; Larsson and Smith, 2011), implying that perceptual expectations affect adaptation and repetition suppression processes in the human brain. An unresolved question, however, is whether the observed effects are due to the fulfilled perceptual expectations or to the altered stimulus probabilities that were used in the previous paradigms to elicit predictions. To address this question we varied the probability of prior face and house stimuli independently of the expectation of the subjects. Subjects' perceptual expectations regarding the occurrence of stimulus category (faces/house) were manipulated by a cue (Egner et al, 2010). Subsequently, category probability was modulated during an adaptation phase (8 images, ET = 250 ms/image, 80% faces/20% houses or the other way around) independently from the predictor cue. Finally subjects made a category decision on ambiguous overlapping face/house composites (Cziraki et al, 2010). We found significant target related fMRI adaptation (fMRIa) in the fusiform and occipital face areas when the adaptor had high probability when compared to low probability of faces. More importantly, although expecting faces increased the target related responses, it had no effect on the observed fMRIa. Our results suggest that it is rather stimulus probability than expectation that affects the repetition-related response reduction of face specific areas of the human brain.

◆ **Motor-visual effects in the recognition of dynamic facial expressions**

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Current theories on action understanding suggest a cross-talk between the motor and the visual system during the recognition of other persons' actions. We examined the effect of the motor execution on the visual recognition of dynamic emotional facial expressions using an adaptation paradigm. Previous research on facial expression adaptation has shown that the prolonged visual exposure to a static facial expression biases the percept of an ambiguous static facial expression away from the adapted facial expression. We used a dynamic 3D computational face model (Curio et al, 2010, MIT Press, 47–65) to examine motor-visual interactions in the recognition of happy and fearful facial expressions. During the adaptation phase participants (1) looked for a prolonged amount of time at a facial expression (visual adaptation); (2) executed repeatedly a facial expression (motor adaptation); (3) imagined the emotion corresponding to a facial expression (imagine adaptor). In the test phase participants always had to judge an ambiguous facial expression as either happy or fearful. We found an adaptation effect in the visual adaptation condition, and the reversed effect (priming effect) in the motor and imagine condition. Inconsistent with simple forms of motor resonance, this shows antagonistic influences of visual and motor adaptation.

◆ **A cross-modal, cross-dimensional mechanism for numerosity perception**

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Previous research has demonstrated that numerosity perception is a primary attribute of the visual system susceptible, like most visual attributes, to adaptation (Burr and Ross, 2008 *Current Biology* **18**(6), 425–428). Here we investigate adaptation to sequentially presented items. The results show that adapting to series of flashes presented at a frequency of 2, 4 or 8 Hz for about 40 s, robustly affects the perceived numerosity of visual pulses (range 2–20) subsequently presented in a temporal window of 2 s. Adapting

to low frequency (2 Hz) increased the amount of subsequent flashes of about 15–20%, and to high frequency (8 Hz) decreased apparent numerosity; 4 Hz had no effect. Similar effects were observed for auditory stimuli. Most interestingly, adaptation also occurred cross-modally: adapting to auditory bursts affected visual numerosity, and vice versa. These results support the idea that similar mechanisms underpin numerosity perception in vision and audition, in both space and time.

TALKS: BRIGHTNESS AND LIGHTNESS

◆ Experiments in perceived illumination

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Classic theorists, like Helmholtz, Hering, and Katz, suggested that perceived illumination within a field is determined by average luminance. Zdravković et al (2011 *Journal of Experimental Psychology: Human Perception and Performance*) reported evidence that illumination is tied to highest luminance. We tested perceived illumination using a new technique. Looking into two square windows in the far wall of a vision tunnel, observers could see a patch of the far wall in each of two chambers. Each patch contained two shades of grey. They turned a knob to adjust the illumination level in one chamber to match that of the other. The stimuli placed in the chambers varied in luminance range, spatial frequency, and relative area. Illumination was matched for highest luminance, not average. Spatial frequency made no difference. Area effects were also found. If an aperture contained a large dark grey region and a small light grey region, illumination level appeared lower and surface lightness appeared higher than if the aperture contained equal light and dark regions. These results, which are consistent with Koffka's invariance theorem and with the role of highest luminance in anchoring theory, provide a foundation for integrating the perception of illumination with perception of surface lightness.

◆ Relationship between constancy and memory for stimulus hue and lightness

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Both constancy and memory have important roles in color-based object identification: constancy aids in scene-invariance of perceived color, and memory links perception across time. Here, we characterize color constancy and memory for stimuli varying in lightness or hue. Observers compared the lightness or hue of two briefly presented 2-degree patches in a 2AFC experiment. Patches were presented (1) with a 2.5-second inter-stimulus interval on a uniform surround (memory condition), (2) simultaneously with a luminance or hue difference in stimulus surround (constancy condition), or (3) with both the delay and the surround difference (combined condition). We fit psychometric functions to the proportion-lighter or proportion-bluer data in each condition and estimated the bias (the point of subjective equality). We developed a probabilistic response model with noise and bias parameters fit to all data from the single-change conditions and predicted the bias in the combined condition. Every manipulation elicited a bias in perceived lightness or hue. Pure memory bias was generally well-described as a tendency towards mean stimulus value. Surround biases were consistent with constancy predictions. The response model predicted the combined bias based on the single-change fits with reasonable accuracy. We conclude that memory and constancy act roughly additively in color perception.

◆ Can a veiling luminance make a black room look white?

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e-mail: alan@psychology.rutgers.edu)

What happens when observers view a miniature room painted black and filled with black objects through the reflection of a homogeneous sheet of light (veiling luminance)? Prior work leads to conflicting predictions. Because all-white rooms produce a low contrast image due to mutual illumination, while all-black rooms produce a high contrast image (Gilchrist and Jacobsen, 1984), a black room seen through a veil should look white due to the reduced contrast produced by the veil. But because lightness constancy is excellent when a 3D image is viewed through a veil (Gilchrist and Jacobsen, 1983), but completely absent when a 2D Mondrian is seen through a veil (unless the edges of the veil are visible), a black room seen through a veil should appear as a black room covered by a veil. Fifteen observers judged the room as white (Munsell 9.0) and none saw a veiling luminance. The fact that the room appeared white even though our stimulus did not duplicate the luminance gradients in a white room shows that the precise shape of the gradients is not important, only the gross level of contrast. A separate group of 15 viewed the room without the veil saw the room as gray (Munsell 6.2).

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◆ **Testing luminance polarity and spatial grouping principles of three recent lightness theories**

M Rudd (University of Washington, USA; e-mail: mrudd@u.washington.edu)

Will varying the luminance of a non-contiguous background affect target lightness? Gilchrist's Anchoring Theory (AT) says "yes" only if the background is the highest luminance. Bressan's Lightness Grouping (LG) and Rudd's Edge Integration (EI) theories predict effects for all backgrounds. Incremental or decremental squares were presented on two sides of a monitor, surrounded by frames of equal luminance but different widths (right narrower). The background was varied from lowest to highest display luminance. Observers adjusted the left square to match the right in lightness. The background was predicted to affect the right square lightness more than the left due to spatial proximity (LG) or edge weight decay (EI), yielding a background effect on matches. This effect was seen at all backgrounds, contrary to AT. But the effect was strongest with highest luminance backgrounds, which can be explained by LG (EI) only if there is an interaction between proximity (edge weight) and frame/background polarity. Incremental target matches were non-monotonic for backgrounds intermediate between the square and frame luminance. Non-monotonicity has been seen in other lightness studies and indicates assimilation (Rudd, 2010 *Journal of Vision* **10**(14) 40, 1–36). I propose a set of principles based on proximity and luminance polarity that any lightness theory must explain.

◆ **Lightness contrast at the leading edge of motion**

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Uniform backgrounds appear lighter or darker when elements containing luminance gradients move across them (first presented by Hiroshi Nakamura at the 2010 Illusion Contest in Japan). This effect is intriguing because it integrates the processing of brightness/lightness, gradients, and motion. We psychophysically investigated the phenomenon by measuring the apparent lightness of a grey background overlaid with moving square patches of vertically oriented luminance gradient. For grey-to-black gradients, the background appeared lighter when the black edges were leading than when they were trailing. For grey-to-white gradients, the background appeared darker when the white edges were leading than when they were trailing. For white-to-black gradients, the background appeared darker with a white edge leading and lighter with a dark edge leading, whereas the effects were weaker. These results demonstrate that lightness contrast can be modulated by motion direction of the inducing patterns. This effect might be partially explained by stimulus enhancement at the leading edge and/or suppression at the trailing edge (eg Arnold et al, 2007 *Vision Research* **47** 2403–2410), but it is also likely to be related to asymmetry in processing spatiotemporal gradients (Murakami et al, 2006 *Vision Research* **46** 2421–2431). [Supported by Global COE program (D07 Kyoto University) by MEXT, Japan, and JSPS Grant-in Aid for Scientific Research (A22243044) for HA.]

◆ **Highest luminance modulates search in complex tasks**

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In a visual scene, surfaces with highest luminance (HL) are considered "special" because they determine the lightness assignment of all other surfaces. This implies that the visual system has implicit access to the relative intensity of the HL. Here, we ask whether the relative location of the HL is also implicitly encoded. We used the MILO task (Thornton and Horowitz, 2004 *Perception & Psychophysics* **66** 38–50) to explore whether the location of the HL influences behavior during sequential search. Each display consisted of nine gray squares, ranging from black to white. Participants clicked on each square in a specific order, either from black to white (BTW) or from white to black (WTB). A located target would either vanish (experiment 1) or remain (experiment 2) on the screen. Finally, all the targets were either brighter than the background (increments, experiment 3), or darker than the background (decrements, experiment 4). Physically removing items did not modify search behavior, confirming the existence of efficient inhibitory tagging previously demonstrated with alphanumeric sequences. WTB search was always more efficient than BTW search except when all targets were decrements. These search benefits suggest that we use implicit knowledge about the position of HL during complex tasks. [This research was supported by Ministry of Education and Science, Grants No. 179033 and III47020.]

TALKS: CONSCIOUSNESS

◆ Temporal constraints on intentional binding and the perception of causality

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The perceived timing of both an action and its visual feedback are altered if humans assume that they are causally linked (Haggard et al, 2002 *Nature Neuroscience* **5** 382–385). However, it is unknown how visual and motor events have to be timed relative to one another to be perceived as causally linked. Two possible criteria apply: (1) The visual and motor event should be maximally close in time. (2) The visual event should occur after the motor event. We tested which of these criteria dominates the human perception of causality. Participants had to press a button and two visual stimuli were presented at variable times shortly before and after the press event. In order to present a visual flash at a given time before the voluntary button press, we predicted the moment of the press in real time from online measurements of finger position. Participants decided (forced choice) whether their button press had caused the first or the second flash. We found a trade-off between the two criteria: There is a window of intentional binding of ca 100 ms where closeness in time dominates causality judgments, even if the visual stimulus leads. For larger visual leads, participants adhere to the criterion that cause precedes effect.

◆ The time course of feature integration in plaid gratings identified by metacontrast masking

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Using oriented gratings in a metacontrast paradigm we recently showed that masking functions—ie the dependence of target visibility on the stimulus onset asynchrony (SOA) between target and mask—are determined by inhibitory processes within and between spatial frequency selective channels. By contrasting collinear and orthogonal target-mask sequences in an EEG/MEG-study we find that within-channel inhibition peaks around 120 ms after target onset. In a behavioral study we present simple grating annuli as masks preceded by either collinear, orthogonal, or plaid targets, or no targets, asking the participants whether a target had been presented, and if so, which one it was. The results for plaid targets show that at short SOAs (10–30 ms) the mask selectively removes the collinear component from the plaid stimulus, causing subjects to perceive it as orthogonal instead. At longer SOAs (50–60 ms) the mask reduces the visibility of the plaid pattern as a whole. We conclude that masks interfere with isolated features at short SOAs and with integrated objects at longer SOAs. In combination with the results mentioned above we infer that the beginning of feature integration precedes within-channel inhibition by around 30 ms, so about 90 ms after target onset.

◆ Priming the recognition of one's own and other faces: perceptual shifts and reaction times

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The recognition of the own and other faces was investigated with morph sequences creating smooth transitions between a portrait of the participant and portraits of three other people (cf. Kircher et al, 2001 *Cognition* **78** B1–B15). In a time-constraint two-alternative forced choice paradigm, participants were asked to reply “yes” if they thought a portrait depicted themselves, and “no” if they did not. The recognition process was manipulated by presenting perliminal (30 ms) primes (Pannese and Hirsch, 2010 *Consciousness and Cognition* **19** 962–968) that either showed the participant's own face or the face of the other person appearing in the current morph sequence. Percentages of answers “yes” were plotted as a function of morph level (ranging from 0 to 100%), yielding a psychometric function for self-recognition. Priming with “self” or “other” increased the probability of recognizing the respective face, shifting the point of subjective equivalence (PSE, 50% level of fitted curves) by about 7% away from the primed face. Reaction times indicated faster response in congruent trials (target picture consists of more than 50% of person shown in prime) of about 40ms as compared to incongruent trials. Taken together, priming-induced PSE-shift and reaction times provide a stable probe for measuring the influence of contextual stimuli on self-recognition.

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◆ **How many roads are there to act upon visual stimuli?**

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It has regularly been proposed that there are different routes of visually based actions. The dorsal visual processing route is thought to be involved when manual actions have to be carried out whereas the ventral route is crucial for judgments about object identity. These findings seem in line with views on consciousness such as the multiple drafts model of consciousness (Dennett, 1991 *Consciousness Explained*, Boston, MA: Little, Brown and Co), and point against a global workspace that guides our actions. In the current study, we examined whether this multiple drafts models is supported by focusing on different effector systems. A diamond was presented either to the left or the right from a fixation dot accompanied by a distracting square on the other side. Participants had to indicate the side of the diamond either by making a corresponding button press, a corresponding saccade, or by giving a verbal left or right response. Meta-contrast masking was employed at various SOAs to manipulate the visibility of the target and distractor. Response accuracy increased as a function of SOA, but importantly, the pattern for the different effectors was indistinguishable. These results favor global workspace models in which incoming visual information is first analyzed before triggering the required action.

◆ **Object-centered binocular suppression**

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In binocular rivalry, one image is perceived consciously whereas the other image is suppressed. It is often thought that binocular suppression results from inhibition between (monocular) neurons coding for the same visual field location and, hence, suppression occurs within retinotopic coordinates. In a binocular rivalry experiment, we presented three disks to both eyes. In the central disk, a low-contrast horizontal or vertical grating was presented to one eye and a high-contrast bull's eye to the other eye. The bull's eye fully suppressed the grating. Next, the three disks were shifted in both eyes to the right by one position, creating apparent motion and, consequently, a non-retinotopic reference frame. In the central disk of frame two, again a horizontal or vertical grating was presented. No bull's eye was presented. Detection of the grating with the previously suppressed orientation was worse than detection of the orthogonal one, even though the gratings in frame one and two were presented at different retinotopic locations. Hence, feature suppression occurred in non-retinotopic, object-centered coordinates. We suggest that binocular rivalry in non-retinotopic coordinates allows the visual system to create binocular perceptual stability despite continuous changes in the retinal images due to eye, object, and head movements.

◆ **Chromatic evoked potentials modulated by hypnosis**

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Prior research has demonstrated that the major negative component of the chromatic visual evoked potential is resistant to modulations from attention, suggesting an early origin for this component. There have been other reports that brain responses in early visual cortex can be selectively suppressed in "multiple personality disorder". In one report, the brain responses were suppressed for blind personalities but not for sighted personalities within a single subject. This result suggests a feedback contribution to early visual areas from regions involved in higher functions (eg) consciousness. We hypothesized that perhaps early visual areas can also be modulated in other manipulations of consciousness such as hypnosis. We tested chromatic and achromatic VEP responses in subjects with and without the hypnotic suggestion of blindness to the visual display of the stimulus. Results showed that the responses of many subjects were suppressed during the suggestion compared to responses before and after hypnotic suggestion. Other subjects' responses were unaffected, consistent with the observation of high variability in suggestibility to hypnosis within the general population. Preliminary controls have ruled out some other explanations of this phenomenon. We continue to test alternative explanations for these results.

TALKS: MULTISENSORY PROCESSING

◆ Early interaction between vision and touch during binocular rivalry: characteristics and constraints

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Growing evidence shows that cross-modal signals can interact at the earliest stages of sensory processing. Haptic signals have been shown to influence the dynamics of binocular rivalry, a form of perceptual bistability (Lunghi et al, 2010 *Current Biology* **20**(4) R143–144). We investigated the role of spatial proximity, type of tactile stimulation (active or passive) and cross-modal attention in promoting fusion between vision and touch during binocular rivalry of orthogonally oriented gratings ($\pm 45^\circ$, size 2.5° , SF 2c cm^{-1}). By varying the tactile orientation ($\pm 7.5^\circ$, $\pm 15^\circ$, $\pm 30^\circ$), we further investigated the orientation selectivity of the interaction. We found that both active exploration and passive tactile stimulation boosted the visual stimulus congruent with the tactile one (engraved grating), both prolonging conscious perception and restoring it from binocular rivalry suppression. The interaction was strictly tuned (less than one octave) matched visuo-tactile spatial frequency and orientation. We also found that voluntary and stimulus-driven attention played a minor role in mediating the interaction, while spatial proximity between visual and tactile stimuli was necessary for fusion of the cross-sensory signals, suggesting that the visual and the somatosensory spatial maps are aligned. Taken together, our results points to a very early multisensory interaction site, possibly V1.

◆ Not glass but plastic—Audiovisual integration in human material perception

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Vision provides useful information about the material of objects. We are able to judge only from visual appearance whether an object is likely to be made of metal, glass, ceramic or wood. Likewise, we are able to judge object's material only from auditory information, such as the impact sound made by striking the object (eg, Giordano, and McAdams, 2006 *The Journal of the Acoustical Society of America* **119** 1171–1181). Then what kind of material do we perceive when the visual appearance of one material is combined with the impact sound of another material? We tested this question for a variety of material, and found a strong audiovisual interaction in material perception. For example, a visual glass appearance paired with a paprika sound was perceived as a transparent plastic, and a visual bark appearance paired with a metal sound was perceived as a coated ceramic. Rating data suggest that the observer perceives such materials as being consistent with both optical properties (eg, transparency, roughness, texture) given by vision and internal properties (eg, hardness, heaviness, emptiness) suggested by audition. Material perception smartly integrates complementary information from different sensory modules. [Supported by Grant-in-Aid for Scientific Research on Innovative Areas (No. 22135007) from the Ministry of Education, Science, Sports and Culture, Japan.]

◆ Content cues can constrain AV temporal recalibration regardless of spatial overlap

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Several studies have shown that the point of perceptual synchrony for audio (A) and visual (V) events can be shifted by exposure to asynchronous AV relationships. Recently, it has been demonstrated that it is possible to concurrently maintain two different, and opposing, estimates of AV temporal synchrony (Roseboom and Arnold, 2011 *PsychSci*). However, some uncertainty remains over precisely what defines a given AV pair such that it is possible to maintain a temporal relationship distinct from other pairs. Another recent study (Heron et al, 2012 *EBR*) suggested that, at least for ecologically arbitrary AV pairs, spatial separation was necessary to achieve multiple distinct AV synchrony estimates. Here we investigated if this was necessarily true, or if the magnitude of difference between AV pairs in that study was insufficient to promote independent grouping of each pair. Using a similar paradigm, we examined whether it is possible to obtain distinct temporal recalibrations using two oriented Gabor patches, arbitrarily matched with high or low frequency pure tones. We found concurrent, and opposite, recalibrations despite the two stimuli being presented in the same spatial location. This result indicates that the content of an AV pair can be used to derive distinct AV synchrony estimates regardless of spatial overlap.

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◆ **Visual search driven by audiovisual synchrony shows a right visual field bias**

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Visual search for a modulating target in a modulating array is much easier when synchronized with an auditory transient. Here we show an asymmetry in synchrony-driven search efficiency across the visual field. Participants viewed a ring of 19 luminance-modulating discs while hearing a modulating tone. The modulating discs had unique temporal phases (-380 to +380 ms; 40 ms steps), with one synchronized to the tone. Participants did a speeded visual search for the synchronized disc, with modulations (auditory and visual) both sinusoidal or both square at 1.3 Hz. Target position was randomized and spatial distributions of search efficiency were compiled. Results show that sine modulations did not facilitate search (chance performance at all target phases), but square-wave modulations did: the target (phase = 0 ms) was frequently chosen, with tight error distributions (~120 ms wide) around zero-phase lag. Spatially, visual search varied over the visual field: error distributions were more tightly tuned temporally on the right side, especially the upper-right quadrant. These results show that synchrony-driven visual search: (i) requires synchronized transient signals, (ii) has a narrow integration window (± 60 ms), and (iii) is spatially biased to the right visual field, suggesting a hemisphereic specialization for synchrony-driven visual search.

◆ **Small rewards modulate the latency of stimulus-driven eye movements**

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Extensive research has demonstrated how rewards can influence the programming and function of saccades in non-human primates. However, little is known about the effects of rewards on the function of eye movements in healthy human participants. Here, the effects of instrumental conditioning of eye movements were investigated in human participants. Specifically, participants were given a small financial reward for making one particular eye movement. Consistent with primate data, participants exhibited faster saccadic reaction times to the rewarded hemifield. When reward was removed this effect persisted. The frequency of participants' errors also illustrated a sustained biasing of the oculomotor system even after reward was removed. A second experiment, using the same paradigm but combining an auditory tone with reward found saccades to the rewarded hemifield were significantly slower across participants than those to the unrewarded hemifield, contrasting to the previous experiments findings. Small monetary rewards were able to successfully induce a sustained bias in the oculomotor system. This result may have potential real world applications with patients suffering with visual biases against exploring a full visual field.

◆ **Multi-sensory integration of audio-visual temporal signals in children with cochlear implants**

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Animal studies (eg Stein 1993) suggest that multi-sensory stimulation is necessary for the normal development of multi-sensory neural mechanisms. We investigated how abnormal auditory input (severe hearing loss) during early infancy can affect human multisensory integration of temporal information. We measured temporal bisection thresholds for auditory, visual and conflictual audio-visual stimuli in 57 typical children and adults, and in 13 children and adults with cochlear hearing devices implanted at various ages. Subjects were required to judge whether the second of a three-pulse sequence was closer to the first or third pulse (separated by 1 sec). In the audio-visual condition, the visual and auditory stimuli were either simultaneous or in conflict. The results show that typically developing adults and children rely primarily on audition for the audio-visual temporal bisection task. However, children with implants gave more weight to visual information. Interestingly, in this group the auditory dominance was restored after about 12 years of auditory exposure, suggesting that the cross-sensory calibration takes some time, but can also occur relatively late in life.

TALKS: CONTRAST

◆ Late development of contrast normalization mechanisms

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Contrast sensitivity is regulated by gain control mechanisms that normalize sensory responses. We studied gain control mechanisms in school-age children (6–16 years) and adults using a visual masking paradigm in which a spatially random 2D noise test pattern was masked by the presence of a superimposed independent noise pattern presented at 0, 12 and 40% contrast. Frequency-tagged Steady State Visual Evoked Potentials were used to separately record responses to the test (5.14Hz) and the mask (7.2 Hz). By incrementally increasing the test contrast we measured contrast response functions for each mask contrast. The unmasked contrast response functions were largely similar in shape but peak amplitude was higher in the children. Masking shifted the adult contrast response function rightward on the contrast axis, consistent with contrast gain control. However, masking impacted children's response functions differently. The main effect of the masker was to reduce response slope, rather than to shift the response function rightward, suggesting that children exhibit more response gain than contrast gain. These results demonstrate that contrast normalization processes are still immature in school-age children.

◆ Representation of category-specific and non-specific information in human inferior temporal cortex

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A classical hierarchical model would assume that visual processing progresses from simple features to complex objects. Indeed, recent neuroimaging and neurophysiology evidence suggests that areas in inferior temporal (IT) cortex are selective to a certain semantic category (eg, FFA, fusiform face area; PPA, parahippocampal place area). However, low-level stimulus features modulate FFA activation (eg, Yue et al, 2011 *Cerebral Cortex* **21**(1), 35–47). Relationship between feature processing and categorical object representation in these visual areas remains unclear. Here we examine both average BOLD and multivariate patterns of fMRI data regarding how category-specific (face versus house) and non-specific (stimulus contrast) information is represented in human IT. The average BOLD in the FFA was modulated by the contrast of faces, but not houses, while the PPA was modulated by contrast of both stimuli. Interestingly, activation patterns in the FFA and PPA were barely affected by contrast at statistically near chance level, whereas the categorical information can be decoded from the patterns at significantly above chance level. Our results affirm that both category-specific and non-specific information is represented in IT. However, stimulus contrast and object category are encoded in qualitatively disassociated ways, suggesting non-hierarchical and separate neural mechanisms underlying feature processing and object representation.

◆ Masking asymmetries reveal a new specificity for face coding

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There is wide agreement that faces are efficiently processed by specialized, independent pathways that treat them as global configurations of particular relevance. Here we studied whether face-specific effects occur as early as the level of visual detection and contrast masking. Stimuli were faces or cars (objects), with both regular and inverted contrast polarity, and noise stimuli obtained by scrambling the phases of each specific image, so that faces/cars and their respective noise images had identical spectra. Contrast discrimination functions were the same for objects masked by noise and for inverted polarity faces masked by noise. There was an asymmetry of masking for positive contrast faces: positive contrast faces elevated noise-contrast discrimination thresholds more than noise masker were able to elevate face-contrast discrimination thresholds, despite the identical spectral content of the two stimuli. These data reveal a novel form of masking asymmetry that is not simply attributable to phase metrics such as phase congruency, and may be linked to efficient coding of visual structures of particular relevance, such as faces.

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◆ **Contrast thresholds for letter identification as a function of size**

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As part of our effort to develop practical models for image identification (Watson and Ahumada, 2005 *Journal of Vision* 5(9), 717–740; Watson and Ahumada, 2008 *Journal of Vision* 8(4), 1–19), we have reviewed the data for contrast thresholds for letter identification as a function of size. All eight studies that we have found, examining letter sizes from 0.04 to 60 degrees, and employing a variety of stimulus materials and conditions, agree that sensitivity increases rapidly with size from the acuity limit, but then saturates, and may decline slightly, for letter sizes above about 1 degree. None of these studies has offered a comprehensive account for this pattern of results. We have explored the performance of an ideal observer limited by optics, eccentricity-dependent retinal filtering and sampling, neural noise, and an efficiency that varies with pattern size. We find that all of these components are required to account for the pattern of results. We consider various explanations for the decline in efficiency with size, and discuss alternative explanations, such as a decline in efficiency with eccentricity.

◆ **Long-range template matching follows spatial inhomogeneity, short-range spatial filtering, square-law contrast transduction and the addition of internal noise**

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Since the 1970s and 1980s, the standard view of spatial vision has been that contrast detection involves probability summation over multiple short-range filter-elements, typical of those found in the primary visual cortex. However, more recent work has favoured a model involving physiological integration of luminance contrast over substantial parts of the image, concluding that in previous studies, the effects of a square-law transducer followed by linear summation of noise with the signal have combined to masquerade as probability summation. Here we addressed the details of the contrast integration process by comparing it to an ideal observer model, which was progressively adjusted until it fitted our area summation results (1 to 32 cycles square). We argue that observers use spatially extensive templates (with diameters of several cycles) that operate on the luminance contrast image, but only after retinal inhomogeneity, short-range filtering, square-law transduction and the addition of internal noise. Ideal templates that are matched to the image after the effects of the three processing stages above, provide the modeler with a convenient implementation but might imply a greater level of sophistication than is needed to explain the results.

◆ **Contrast energy discrimination thresholds for blur and contrast compared**

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Watson and Ahumada (*Journal of Vision* 2011) predicted blur discrimination thresholds from contrast energy differences weighted by the appropriate human contrast sensitivity function. Many aspects of previously published results were accurately predicted but thresholds for blur tended to be lower than predicted. To compare blur discrimination and contrast discrimination thresholds with the same stimuli, we used a standard chess board stimulus with contrast 0.5 and blur 5 arcmin, and also measured the ability of observers to discriminate changes in blur and contrast using a 4-key response. Contrast Energy Thresholds were higher (~ 1.5 x) for contrast than for blur discrimination, and blur and contrast changes could be discriminated at their respective energy thresholds in a manner consistent with two channels, inheriting the same contrast energy noise, but with independent late noise.

TALKS: AFTEREFFECTS

◆ **Neural correlates of affective judgments with visual stimuli**

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Our perception of many visual stimuli is accompanied by implicit or explicit assessments of how 'likable' they are. An image of a bowl of cherries, for instance, is attractive while one of moldy bread is not. Here we report results from our electrophysiological studies that were designed to identify the neural correlates of these judgments. Our stimuli depicted food or non-food items with sub-classes of appealing or unappealing exemplars. We sought to determine whether these four classes of stimuli could be distinguished based on the patterns of brain activity they elicited, the consistency of responses across subjects, as well as the time-course of emergence of these responses. Subjects passively viewed 200 visual stimuli (50 from each class) while their brain activity was recorded using magneto-encephalography (MEG). We found compelling differences in brain activity patterns corresponding to the four stimulus

classes, with the first distinction emerging as early as 85 ms post stimulus onset. The identification of these neural correlates furthers our understanding of the substrates of affective judgments and has applied implications in the domains of design and evaluation.

◆ **Influences of spatial and featural endogenous attention on pattern rivalry for afterimages**

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Perceptual multistability can result from ambiguous sensory input consistent with multiple perceptual interpretations. In such cases, including monocular rivalry, binocular rivalry, perception of ambiguous figures, and the like, visual experience tends to alternate between several perceptual interpretations of the stimuli. Understanding what mechanisms contribute to the selection of a particular interpretation for perceptual dominance during perceptual multistability may provide clues to the selection processes that influence the contents of visual perception under normal circumstances. Here, we demonstrate that endogenous attention can influence perceptual dominance for afterimages engaged in (monocular) pattern rivalry, much as exogenous cues such as contour presence can (see van Lier, Vergeer, and Anstis, 2009). Using rivalrous afterimages of overlapping, colored, transparent textures and a post-adaptation auditory attentional cue, we find that endogenous attention can lengthen the dominance period of the attended stimulus. We performed additional experiments to isolate the contributions of spatial and featural attention to the effect. The results of those experiments suggest that spatial and featural attention have dissociable effects that can combine additively. Thus, our findings suggest that different types of endogenous attention can contribute to the selection of particular perceptual interpretations in pattern rivalry for afterimages.

◆ **Dichoptic positive color after image is limited for the number of colors presented within a display**

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We have reported that negative color afterimage is enhanced when the adapted are is surrounded by a luminance contour in the test phase. In addition, positive color afterimage (PCAI) is observed when the inducer was presented to the opposite eye (2010 *Perception* **39** ECVS Supplement). It is well known that black and white photos appear colored when viewed after adapting to a complementary color image. However, PCAI was never observed when a B/W photo was presented to the opposite eye as for dichoptic PCAI. This suggests that the occurrence of PCAE is limited by spatial complexity, or number of colors. To test these possibilities, we examined the dichoptic PCAE by varying number of divide areas and/or colors using curved Mondrian patterns. The stimulus was a 15 x 9 deg rectangle divided into either 7 or 30 sections and each sections was filled with one of either 2, 4, 12, or 30 different colors. The results indicated no effect of number of colors, but clear effects of number of areas were revealed. These results therefore indicated that dichoptic PCAE occurs only for patterns with relatively simple spatial configuration, and suggest the absence of dichoptic PCAE in photographic stimulus arises from the same limitation.

◆ **Emotional action aftereffects indicate dual emotion coding mechanisms**

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Face aftereffects suggest partially independent coding of facial expressions and facial identity (Fox and Barton, 2007 *Brain Research* **1127**(1), 80–89). Bodily actions can also convey actor identity and emotional state. We investigated the mechanisms involved in recognising emotions from whole body actions using a visual adaptation paradigm. Following adaptation to actions performed in either a happy or sad fashion participants interpreted subsequent actions performed in a neutral fashion as portraying the opposite emotion. Emotional action aftereffects were stronger when the identity of the actor in the adapting and test stimuli was the same, than when it was different. Both identity dependent and identity independent emotional action aftereffects increased with the duration of the adapting stimuli. However, the different identity aftereffect quickly decayed over time, while the same identity aftereffect had still not decayed after 10.8 sec. These findings suggest that adapting to emotional actions influences 2 separate mechanisms. Following adaptation, an identity independent emotional action coding mechanism shows visual aftereffects with dynamics similar to other high-level aftereffects. A second identity dependent emotional action coding mechanism, however, shows different adaptation dynamics, where adaptation

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results in a long lasting recalibration of the perceived emotion derived from the actions of the observed individual.

◆ **Attractiveness of face photographs: Adaptation effects and spatial frequency characteristics in the Fourier domain**

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We studied visual adaptation on face attractiveness (defined as the physical allurements of a person). First, we found an adaptation effect on attractiveness of non-morphed photographs of human adult faces. This adaptation effect is non-symmetric, suggesting that adaptation on attractive face photographs has a larger effect than on unattractive faces. The observed effect may relate to the finding that attractive faces are more tightly clustered in psychological face space than unattractive faces (Valentine and Bruce, 1986 *Perception* **15**(5), 525–535). Next, we asked whether the rating of attractiveness is correlated with image properties that have been previously associated with aesthetic visual perception, ie their spatial frequency spectra in the Fourier domain (Graham and Redies, 2010 *Vision Research* **50**(16) 1503–1509). We demonstrate that Fourier power and the slope of log-log plots of radially averaged (1d) Fourier power correlates with the attractiveness ratings obtained in the previous experiment. In conclusion, the adaptation study suggests that specific neural circuits mediate the perception of face attractiveness in the human visual system. Moreover, beyond individual preferences, face attractiveness ratings are associated with measurable, higher-order statistical properties of the face images.

◆ **Does top-down information influence the afterimage illusion?**

S Utz, C-C Carbon (University of Bamberg, Germany; e-mail: sandra.utz@uni-bamberg.de)

The afterimage illusion refers to a (complementary coloured) image continuing to appear in the observer's vision after the exposure to the original image has ceased. It is assumed to be a phenomenon of the primary visual pathway, caused by overstimulation of photoreceptors of the retina. According to Hering's opponent process theory, the more fatigue of certain pathways the stronger the probability of producing antagonistic visual impression, for instance overstimulation evoked by areas of red will produce an afterimage of green. Aim of the present study was to investigate the origin of afterimage perceptions, mainly whether it is a mere physical effect or whether it can be influenced by top-down processes, eg by an implicit memory task. Using a priming paradigm, participants were presented with five either strongly female or male faces, followed by a negative image of an androgynous face which had to be fixated for 20s. Participants had to rate their afterimages according to sexual dimorphism. Results showed that the afterimage of the gender-neutral face was perceived as significantly more female in the female priming condition in comparison to the male priming condition (medium effect size). Our results clearly argue for a prominent influence of top-down processing on the afterimage illusion.

THURSDAY

TALKS: ATTENTION III

◆ **Measuring the frame rate of visual perception—the role of brain oscillations in the temporal segregation of visual events**

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Despite phenomenologically continuous, increasing evidence suggests visual perception to be discrete and points to the outstanding role of ongoing brain oscillations. We addressed this empirical question using a forward masking procedure with variable stimulus onset asynchrony (SOA), while the observers were engaged in an enumeration task. Concurrently we recorded electrophysiological brain activity using MEG. Enumeration is a particularly interesting task in this context, as a small number of items (up to four) is supposed to be simultaneously apprehended in one instant—a phenomenon called subitizing. The to be enumerated items were superposed upon the masking pattern, so that the performance melioration with increasing mask-target SOA in this task supposedly depended upon the observer's accumulative ability to segregate the temporal onset of mask and target displays. We hypothesize that correct trials indicate temporal segregation, while incorrect trials are associated with temporal integration of mask and target information. We searched for power and phase differences between these proportions of trials at pre- and peri-mask intervals and found evidence supporting the idea that oscillatory brain activity could mediate between temporal integration and segregation of visual events and therefore serve as a frame rate of visual perception.

◆ **A computational model of microsaccadic responses to shifts of covert attention**

R Engbert (University of Potsdam, Germany; e-mail: ralf.engbert@uni-potsdam.de)

Even when we fixate an object of interest, our eyes perform miniature (or fixational) eye movements, which are classified as slow movements (physiological drift) and microsaccades. Suddenly upcoming stimuli in the periphery induce covert attentional shifts which are followed by a saccadic eye movements later on. Before the saccadic response, however, microsaccades are modulated in terms of their rate-of-occurrence as well as their spatial orientations. I present a computational model that integrates lower-level perceptual responses and higher-level attentional signal to reproduce behavioral findings on fixational eye movements. Microsaccadic rate modulations as well as the temporal variation of the orientation bias of microsaccades can be predicted from the model. Using extensive numerical simulations, it turned out that the type of the attentional cue (endogeneous or exogeneous) and the temporal delay between perceptual onset and the resulting attentional shift are critical for the pattern of results observed in experiments. Results are relevant to the more the general problem of integration of low-level perception and top-down cognitive processes in sensorimotor control.

◆ **Perceptual learning at the location of predictive remapping**

M Rolfs¹, N Murray-Smith², M Carrasco² (¹New York University and CNRS, Université Aix-Marseille, France; ²New York University, USA; e-mail: martin.rolfs@nyu.edu)

Just before the eyes move, predictive remapping of visual attention facilitates perception at future relevant locations (Rolfs et al, 2011 *Nature Neuroscience* **14** 252–256), providing a functional account of anticipatory responses in many retinotopic brain areas when an imminent saccade will bring a stimulus into a neuron's receptive field (Duhamel et al, 1992 *Science* **255** 90–92). Here, we examine the impact of predictive remapping on visual processing using a perceptual learning protocol. Observers performed a fine orientation discrimination task ($\pm 5^\circ$ off a predefined reference), judging a peripheral Gabor embedded in noise. Over five days of training, observers made a saccade following a stereotypic step of the fixation spot while the Gabor always appeared just before the eye movement. Contrast thresholds decreased continuously—the signature of learning. During the final three days, observers maintained fixation and we tested whether learning transferred to (1) the remapped location of the training stimulus (offset from training location by the inverted saccade vector), or (2) a spatially matched control location (same distance as remapped location from training location). Observers' thresholds at the remapped location were significantly lower than at the control location. This enhanced visual sensitivity indicates that learning transferred under predictive remapping.

Thursday

◆ **Trans-saccadic priming of location and orientation**

K Ritchie, A Hunt, A Sahraie (University of Aberdeen, UK; e-mail: kay.ritchie@abdn.ac.uk)

We experience visual stability despite shifts in the retinal array produced by saccades, but the mechanisms supporting stability are the subject of some debate. We have previously shown that a pre-saccadic prime in the blind visual field of hemianopic participants leads to increased detection and discrimination in that location when it is brought into the sighted field by an eye movement. Here we replicated this finding in neurologically intact controls using briefly-presented pre-saccadic primes. Discrimination of post-saccadic targets was more accurate when they were presented in the same location as the prime than when there was no prime or the prime was in a different location. In our second experiment we examined the effect of the orientation of the pre-saccadic prime on discrimination of the orientation of the post-saccadic target. Performance was significantly improved when the prime was presented in the same orientation as the target. This orientation-based facilitation was limited to targets in the same retinotopic location as the target, and to a lesser extent, the same spatiotopic location as the target. The results suggest that location and, to a lesser extent, orientation information are maintained in spatiotopic coordinates when saccades shift visual input across the retina.

◆ **How does memory search interact with the attentional blink?**

T Drew, A M Sherman, J M Wolfe (Brigham and Women's Hospital, USA;
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Humans are remarkably good at identifying target objects in Rapid Serial Visual Presentation (RSVP) sequences of objects. However, suppose observers must hold several possible targets in memory (Monitor the stream for cow, spoon, pen, or key). This necessitates hybrid search of memory and of the RSVP stream. In visual search tasks, the amount time needed to evaluate each item increases linearly with the log of the number of possible targets (Wolfe, in press, *Psychological Science*). In RSVP, we have shown that the presentation rate required to reach a criterion target detection rate increases as a function of the log of the number of possible targets (Drew and Wolfe, 2012, VSS). Does memory search for a match to the current item in an RSVP stream influence processing of subsequent items in the stream? To answer this, we used a modified attentional blink paradigm. T1 was an object that needed to be matched to the memory set. If T2 was an object, the magnitude of the 'blink' produced by T1 was strongly dependent on memory set size. However, if T1 was an object and T2 a number, T1 produced the same magnitude blink regardless of memory set size.

◆ **Differential involvement of dorsolateral prefrontal cortex in difficult visual search: a TMS study**

G Pobric, J Hulleman (University of Manchester, UK; e-mail: gorana.pobric@manchester.ac.uk)

Recently, Young and Hulleman (JEP:HPP, in press) proposed a new theoretical framework for visual search. The framework models visual search as a sequence of fixations where items are processed in parallel within a fixation. Crucially, the difficulty of the search task determines the number of items processed per fixation. If the search task is easy, many items will be processed, but when the search task is very difficult only a single item will be processed. We tested this assumption with transcranial magnetic stimulation (TMS). Participants searched for T amongst L (medium search) or for a square with a smaller square in the left top corner amongst squares with a smaller square in one of the other corners (difficult search). Display size was manipulated to equate tasks for search times. Low frequency repetitive TMS (1Hz for 10 min at 64% of machine output) was applied offline over the right frontoparietal network. Performance was selectively impaired for difficult search after dorsolateral prefrontal cortex (DLPFC) stimulation, suggesting a crucial involvement in the precise saccadic targeting and increased attentional control demanded by difficult search. This finding supports fundamental distinction between very difficult search and easier search made by the framework.

◆ **Confusion: some strategies to prevent successful object tracking**

N Scott-Samuel¹, G Holmes², R Baddeley¹, I Cuthill¹ (¹University of Bristol, UK; ²Cardiff University, UK; e-mail: n.e.scott-samuel@bris.ac.uk)

What factors influence one's ability to track a target object moving amongst dynamic distractor items? Biologists hypothesise a "confusion effect": the idea that predation success decreases as prey group size increases. This concept resonates with the human visual search literature, and has implications for the general question of how to hide in a crowd. We used a novel version of a standard multiple object tracking display. Subjects tracked one object amongst several, and errors in locating the final position of that object were recorded. The predictability of all objects' motion paths was systematically varied,

as was their number. In experiment 1, we compared the effect of using background-matching and two-dimensional “dazzle” (high contrast binary) textures on plain or textured backgrounds. In experiment 2, we manipulated number and area. Subjects were at ceiling for stimuli with relatively predictable paths. At higher levels of unpredictability a confusion effect appeared, and then increased with decreasing path predictability. This increase was greater for larger numbers of objects. Surprisingly, varying the textures of objects and background had no effect. Finally, density, not number, influenced error rates. So for optimal confusion, don’t bother with colouration; the critical factors are the unpredictability and density of your group.

◆ **Stimulation of the left parietal lobe improves sustained attention in right parietal lobe patients: tipping the inter-hemispheric balance with TMS**

S Agosta, F Herpich, L Battelli (Italian Institute of Technology, Italy; e-mail: sara.agosta@iit.it)

Right parietal patients are impaired at performing visual tracking of multiple objects. In particular they have difficulties in tracking moving stimuli in the left visual field during simultaneous presentation of another similar target in the opposite hemifield, a deficit likely caused by extinction (Battelli et al, 2001). One of the hypothesis is (Kinsbourne, 1977) that extinction is a consequence of an increased inhibition exerted on the damaged hemisphere by the hyperactive unaffected hemisphere. Here we used transcranial magnetic stimulation (TMS) on the healthy hemisphere to tip the balance between hemispheres and relieve extinction symptoms. Methods: Patients underwent two counterbalanced sessions: low frequency TMS over the left (healthy) parietal lobe and sham control stimulation. We compared their performance before and after TMS. Subjects were asked to track 2 (unilateral condition) or 4 (bilateral condition) moving discs amidst moving distracters (8 total discs, four in each hemifield) in the left and/or right hemifield. Results: Patients’ performance improved immediately after TMS and continued to improve in the next 30 minutes for both unilateral and bilateral conditions. Conclusion: TMS might have beneficial effects on rehabilitation of extinction re-balancing the activity of the two parietal lobes by suppressing the inhibiting activity of the unaffected hemisphere.

TALKS: MODELS AND THEORY

◆ **Temporal precision in interception is surprisingly insensitive to image rate**

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People can swing a bat to hit a ball with a standard deviation in the timing of only about 7 ms. The temporal variability when hitting virtual targets is larger. We wondered whether this could be due to the intermittent presentation of virtual targets. To find out, we asked subjects to intercept moving targets by tapping on them with their index finger. The targets were 1.5 cm diameter disks that moved rightwards at about 40 cm s^{-1} across a large 120 Hz screen. Images of the smoothly moving target were presented for a single frame at 24, 30, 40, 60, or 120 Hz, with the luminance adjusted to the frame rate so that they all appeared to be equally bright (but some appeared to flicker somewhat). We defined timing error as the time between when the finger hit the screen and when the target centre passed the (horizontal) position at which it did so. Subjects hit the targets about 700 ms after they appeared (17 images at 24 Hz). The standard deviation in the timing error was about 12 ms, irrespective of the image rate. At low image rates this standard deviation is considerably smaller than the interval between the images.

◆ **Redundancy reduction: A possible explanation for the inhomogeneous patterns of antagonistic surrounds found in Middle Temporal (MT/V5) neurons**

J A Perrone¹, R J Krauzlis² (¹University of Waikato, New Zealand; ²Laboratory of Sensorimotor Research, NEI, NIH, USA; e-mail: jpnz@waikato.ac.nz)

It is well established that motion sensitive MT neurons have an inhibitory region outside of their classical receptive field (crf) but no good explanation has been found for the fact that the inhibitory zones do not completely surround the crf but rather form inhomogeneous patterns around it (Xiao et al, 1997 *Cerebral Cortex* 7662–677). It is hard to reconcile these patterns with standard centre-surround spatial inhibition models. In the process of developing an image-velocity estimation model based on the outputs from a small number of MT neurons we discovered that these local patterns of inhibition could form part of an overall mechanism designed to reduce the amount of spatially redundant velocity signals fed to the next stage of motion processing (MST). We tested this idea by stimulating our velocity sensors and model MT pattern units (Perrone and Krauzlis, 2008 *Journal of Vision* 8(9) 1, 1–14) using small patches of moving dots similar to the Xiao et al stimuli. With the inclusion of inhibition between adjacent MT units

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we were able to reduce the amount of redundant velocity signals and to replicate (and account for) the patterns of inhibitory zones found in the Xiao et al sample of MT neurons.

◆ **Learning a spatio-temporal correlation**

D Narain¹, P Mamassian², R J van Beers¹, J B J Smeets¹, E Brenner¹ (¹Vrije University, Netherlands; ²Université Paris Descartes, CNRS, France; e-mail: d.narain@vu.nl)

We investigated whether participants could learn a space-time correlation without observing motion and how such learning depended upon experienced stimuli. Participants had to move a stylus to pass through a cued target position at the moment that the target was present. The target was only present for 100 ms, so participants had to anticipate when it would appear. Unbeknownst to the participants, when it appeared depended linearly on its horizontal position. Participants were divided into groups depending on how the stimuli were presented from trial to trial. For one group, stimulus positions were drawn independently from a Uniform distribution. For another group, stimuli changed position following a low-noise Random walk. In the latter case, good performance could be achieved by responding in accordance with the timing of the previous stimulus, without actually learning the spatio-temporal correlation. Participants quickly learned the correlation for the Uniform distribution. While performance was clearly better for the Random walk, when participants were later tested on uniformly distributed stimuli their performance showed that they had not actually learned the correlation. We conclude that participants can learn a space-time correlation without observing motion, but only if consecutive stimuli are drawn from separate parts of the space-time relationship.

◆ **Impaired peripheral reaching and on-line corrections in patient DF: optic ataxia in visual form agnosia?**

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An influential model of vision suggests there are two visual streams within the brain: a dorsal occipito-parietal stream which mediates action and ventral occipito-temporal stream which mediates perception. One of the cornerstones of this model comes from DF, a patient with visual form agnosia after bilateral ventral stream lesions. Despite her inability to recognize visual objects it has been shown that she can execute visually-guided actions towards them with a high-level of skill. These observations have been widely interpreted as demonstrating a double dissociation from optic ataxia, a condition observed after bilateral dorsal stream damage in which patients are unable to act towards objects that they can recognize. One major criticism against this view is that, while the visuomotor deficits in optic ataxia are typically manifest only with peripheral visual guidance, the integrity of action toward peripheral targets has not been closely examined in DF. Here we addressed this question, by asking DF to reach to stationary visual targets and also to perform fast on-line corrections in response to jumping targets, both in free and peripheral vision. Surprisingly, DF was remarkably inaccurate when reaching to peripheral stationary targets, but not when she was allowed to foveate the same targets. Moreover, she was also significantly impaired at correcting her reaches to target jumps, even in free vision. Our data suggest that DF presents visuomotor deficits surprisingly similar to those observed in optic ataxia, when tested under appropriately matched conditions.

◆ **Decision-making under time constraints supports sampling-based representation of uncertainty in vision**

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Increasing body of psychophysical evidence supports the view of human perception as probabilistic inference that relies on representations of uncertainty about sensory stimuli and that is appropriate for statistically optimal decision making and learning. A recent proposal concerning the neural bases of these representations posits that instantaneous neural activity corresponds to samples from the probability distribution it represents. Since these samples are drawn sequentially, a crucial implication of such sampling-based representations is that precision of representing uncertainty will depend on the time available. To test this implication we created an orientation- matching task in which the subjects were

presented several differently oriented line segments. We measured both subjects' performance and their level of uncertainty as they matched the orientation of a randomly chosen element from the previously presented stimulus. We varied the stimulus presentation time trial-to-trial to influence the number of samples available before making a decision. We found that subjects' performance and uncertainty judgment were correlated. Importantly, with decreasing the presentation time this correlation decreased significantly while the performance levels did not change. Thus, limiting the available time specifically influences the reliability of uncertainty representation, in agreement with sampling-based representations of uncertainty in the cortex.

◆ **Predicting eye movements in a contour detection task**

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Grouping local image elements into meaningful objects is a major task for the visual system. Hereby, an important process is contour integration, in which collinearly aligned local edges are merged into global contours. Recently, we developed a probabilistic model of contour integration which explains human contour detection behavior to a previously unprecedented degree (Ernst et al, *PLoS Comp. Biol.* in review). Given this performance, we wondered whether the model might also explain the spatiotemporal dynamics of contour integration. As an indicator for these dynamics, we here focus on trajectories of eye movements during contour detection, hypothesizing that subsequent fixations preferentially visit 'hotspots' of neural activity which emerge during the integration process. In particular, we combine model simulations with recent experimental data (van Humberg et al *Perception* **40** EVCP Supplement, 192), in which eye movements were measured while human observers searched for a target contour embedded in a background of randomly oriented edges. The model was first used to predict potential locations for saccade targets, which were then compared to the real saccades. The target contour's position was reliably predicted for stimuli in which also the majority of observers found its correct location, but not for stimuli where humans failed to identify the target. In addition, our model also predicted a large fraction of saccade targets visited before the actual contour was found, thus confirming both, our hypothesis, and the validity of our model.

◆ **Predicting performance in natural scene searches**

M Asher¹, I Gilchrist¹, T Troscianko¹, D Tolhurst² (¹University of Bristol, UK; ²University of Cambridge, UK; e-mail: psmfa@bristol.ac.uk)

Completely natural scene search is a paradigm that cannot be directly compared to the typical types of search task studied, where objects are distinct and definable. Here we have look at the possibility of predicting the performance of humans for completely natural scene tasks, using a direct comparison of human performance against new and existing computer models of viewing natural images. For the human task, 25 participants were asked to perform a Target Absent/Target Present search task on 120 natural Scenes. The identical task was given to a selection of reproductions of existing computer processing techniques, including Feature congestion (Rosenholtz, Li, Mansfeld, and Jin, 2005 *SIGCHIpp* 761–770), Saliency (Itti and Koch, 2001 *Journal of Electronic Imaging* **10**(1), 161–169), Target Acquisition Model (Zelinsky, 2008 *Psychological Review* **115**(4), 787–835) and a new variation on the Visual Difference Predictor (To, Lovell, Troscianko, and Tolhurst, 2008 *Proceedings of the Royal Society B-Biological Sciences* **275**(1649), 2299–2308) These results lead us to conclude that in natural search tasks, the nature of both the Scene and the Target are important, and that the global influence of local feature groups can have an influence of the task difficulty.

◆ **Bayesian perception of orientation-dependent line length predicted by natural statistics**

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The perceived length of a line depends on its orientation, such that vertical lines are perceived as longer than horizontal lines of the same length (Craven, 1993 *Proceedings of the Royal Society B* **253**101–106), in a manner consistent with the natural statistics of line length (Howe and Purves, 2002 *Proceedings of the National Academy of Sciences of the USA* **99**13184–13188). Here, we describe a method for estimating a Bayesian prior for the orientation-dependent perception of line length. The method was initially tested by recovering the known prior of a synthetic subject, and was then used to estimate the prior for each of five human subjects. These priors are in close agreement with the natural statistics of line orientation, suggesting that humans use the optimal prior for Bayesian inference of line length.

Thursday

TALKS: ART AND VISION

◆ Why must visual stimuli be so poor?

J Ninio (Laboratoire de Physique Statistique, Ecole Normale Supérieure, France;
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Striking illustrations find their place in popular books on visual perception. However, the stimuli used for acquiring psychophysical results are usually devoid of visual interest, eg, (i) strictly minimal stimuli with a small number of dots or segments (ii) sandpaper-like random dot stereograms (iii) horizontal or vertical gratings (iv) figures with Gabor patches. There are hidden, debatable assumptions underlying the design of these stimuli, for instance : (i) The brain does not need a rich environment to appreciate geometrical relationships. (ii) The brain works on a Cartesian x-y array of dots (or neurons) and stereo depth is merely computing a z-coordinate. (iii) Electro-physiology tells us all that really matters for the brain. (iv) illusory effects in complex stimuli merely capture pathological functioning modes of the brain. I will present a selection of illustrations from my popular science or academic publications that, in my opinion, are a good antidote to classical statements derived from psychophysical work on poor stimuli. Paradoxically, it might be that some of the psychophysicist's preferred stimuli are ideal ones for making the brain work in pathological ways.

◆ Color, music, and emotion

S Palmer, K Schloss, T Langlois (University of California, Berkeley, USA;
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Are color and music systematically related for non-synesthetic people? Forty-eight participants picked the 5 colors that went best (and later the 5 colors that went worst) from an array of 37 colors for each of 18 brief samples of classical orchestral music. The music varied in composer (Bach/Mozart/Brahms), tempo (slow/medium/fast), and mode (major/minor). Participants also rated each musical selection and each color for its emotional associations (happy-sad, lively-dreary, strong-weak, angry calm). Faster music and major mode were associated with lighter, more saturated, yellower colors, whereas slower music and minor mode were associated with darker, desaturated, bluer colors. More-controlled single-line piano melodies by Mozart produced better articulated color-music relations, but similar results occurred for 34 different kinds of popular and world music. Strong evidence for emotional mediation comes from extremely high correlations (0.90–0.98) between the music and the colors chosen to go with them (eg, happy colors go with happy music and dreary colors go with dreary music). Analogous effects were obtained when people picked the colors that went best (and worst) with emotional faces (happy-sad and angry-calm) and when they picked the emotional faces that went best (and worst) with the music. Emotion mediates color-music associations.

◆ ERP correlates of visual symmetry perception

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The psychological response to visual symmetry has been studied for more than 100 years. We conducted two EEG studies exploring neural responses to different types of symmetry. In study 1, we contrasted three types of rigid transformation (reflection, rotation and translation) with matched random patterns. We found that ERPs amplitude was more negative for the regular patterns than the random patterns from around 250 ms to the end of the trial. This component is known as the Sustained Posterior Negativity (SSN), and interestingly, it did not differ between regularity types. In study 2, different groups of participants actively discriminated between reflection and random patterns, or between rotation and random patterns. Reflectional symmetry produced the SSN, and source localization techniques identified generators in the extrastriate visual cortex. Rotational symmetry produced an unexpected modulation of early P1 and N1 components. Finally, we analysed the EEG signal in the time-frequency domain, and found that all patterns were associated with desynchronization in the upper alpha frequency band, indicating cortical excitation. Desynchronization was more pronounced over the right posterior regions in some experiments. We conclude that psychophysical differences between different types of visual symmetry map systematically onto EEG metrics, but only under active classification conditions.

◆ **Neural correlates of perceptual pleasure and “Aha” experiences triggered by perceptual flips in ambiguous images**

J Stevanov¹, M Uesaki², H Ashida², T Carlson³, G Cupchik⁴, A Kitaoka¹ (¹Ritsumeikan University, Faculty of Letters, Dept of Psychology, Japan; ²Kyoto University, Graduate School of Letters, Dept of Psychology, Japan; ³University of Maryland, Maryland Vision Science Lab, Dept of Psychology, USA; ⁴University of Toronto Scarborough, Dept of Psychology, Canada; e-mail: akitaoka@lt.ritsumei.ac.jp)

Parahippocampal cortex has previously been implicated in perceptual pleasure. Highly preferred and “richly interpretable” images are associated with greater activity in PPA, an area with a high density of μ -opioid receptors (Yue et al, 2007 *NeuroReport* **18** 525–529). We hypothesized that the positive emotional experience associated with the “Aha” moment would increase activity in PPA. We used fMRI to measure brain activity while participants viewed ambiguous paintings of Ocampo, Arcimboldo, DelPrete and Utagawa, each of which has distinct local and global interpretations. In each trial, stimuli were slowly demagnified starting from local details and ending with the global view. Subjects pressed a button the moment they recognized the global figure (eg face). This gradual deployment of the stimulus allowed us to uncouple activity associated with the stimulus from that associated with the “Aha” experience. Different patterns of brain activity were observed in occipito-temporal lobe, visual areas and a variety of other brain regions associated with aesthetic responses to visual art. Critically, we found activity in PPA was associated with the moment of the perceptual “flip”. We suggest that the pleasure associated with the “Aha” experience is reflected in activity in PPA.

◆ **Art versus reality—contextual framing affects emotional and aesthetic evaluations of artworks and IAPS pictures**

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In the perception of art, negative or disturbing contents are sometimes enjoyed. It can be surmised that an aesthetic context produces changes in the emotional and aesthetic experience leading to positive evaluations of emotionally negative stimuli (Leder, et al, 2004 *British Journal of Psychology* **95** 489–508). To test this hypothesis, we manipulated context by framing either an art or reality context while participants evaluated positively or negatively valenced contemporary artworks and non-art IAPS pictures. We measured aesthetic responses by assessing liking, and emotional responses by collecting ratings of joy, anger, disgust, fear, and sorrow as well as recording facial EMG. Negative artworks were indeed rated as more positive (ie, higher liking and joy ratings) in an art compared to a reality context. Moreover, stronger zygomaticus activations indicated higher positive affective reactions to negative artworks in an art compared to a reality context. For IAPS pictures, context influenced ratings of joy in a similar way as in artworks. However, for both stimuli classes, context had no influence on evaluating negative emotions of anger, disgust, fear and sorrow. This study demonstrates that art context enables processes which allow a more positive evaluation of negative stimuli, thus discarding the immediacy of emotions.

◆ **Relating subjective with objective measures of complexity in affective environmental scenes and representative paintings**

M Marin, H Leder (University of Vienna, Austria; e-mail: manuela.marin@univie.ac.at)

Visual complexity has been found to be related to subjective measures of preference, pleasantness and beauty. However, previous research does not provide a clear picture about the nature of this relationship, and objective measures of complexity in combination with subjective ratings may help to resolve this issue (Forsythe et al, 2011 *British Journal of Psychology* **102** 49–70). The emotional content of visual stimuli has been neglected in prior studies but is crucial in many everyday contexts and particularly when experiencing visual art. We thus compared the relationship between measures of subjective and objective complexity (four compression formats, Canny edge detection and perimeter detection) in a series of four experiments, each employing either a set of 96 IAPS pictures or 96 representative paintings varying in emotional contents (pleasantness and arousal) and complexity (low versus high). Ratings of familiarity, complexity, pleasantness and arousal were obtained under short (5s) and long (25s) presentation times. Analyses indicate that (1) the patterns of relationships between objective and subjective measures of complexity vary across stimuli sets, whereas (2) the relationships between the four subjective ratings are similar, and that (3) presentation time has a minor effect on these relationships in art perception.

Thursday

◆ **Think global, act local: Do local visual processing biases explain proficiency in observational drawing in non-autistic individuals?**

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Exceptional graphical abilities in autistic savants have been explained by enhanced local visual processing, coupled with an intact global advantage effect under voluntary selective attention (Plaisted, Swettenham and Rees, 1999 *Journal of Child Psychology and Psychiatry* **40** 733–742). Furthermore, it has been suggested that non-autistic children who are precocious at drawing exhibit the same local processing hallmarks as their autistic savant peers (Drake, Redash, Coleman, Haimson and Winner, 2010 *Journal of Autism and Developmental Disorders* **40** 762–773). Similar effects have been seen in artistic adults whose drawing experience was correlated with reduced holistic processing in face perception tasks (Zhou, Cheng, Zang and Wong, 2011). In an initial study performance on the embedded figures task (EFT), a measure of local visual processing, independently predicted both self-perceived and objectively assessed drawing ability. This finding was examined in a study that probed both local and global visual processing in art students and controls using Navon shape stimuli, the Block Design Task (Shah and Frith, 1993 *Journal of Child Psychology and Psychiatry* **34** 1351–1364) and the attention to detail subscale of the Autism Spectrum Quotient. The results are discussed with reference to perceptual enhancement theories of observational drawing ability.

◆ **Simultaneous contrast and depth effects from “true” colors on grey backgrounds: Chevreul’s laws of color and contrast revisited**

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Chevreul’s (1839) general laws of “color” and “contrast” predict that colors on achromatic (grey) backgrounds are the least likely to produce mutual interactions affecting our perception, and that the luminance contrast of a color directly determines its likelihood to stand out in depth against the background. We show that colored squares of brighter and darker luminance placed on either side of equiluminant grey backgrounds produce simultaneous contrast effects where assimilation and contrast may occur in one and the same configuration, regardless of color, contrast, or polarity of inducers. Probabilities of no effect, contrast, and assimilation (3AFC between background on left seen as “brighter”, “darker”, or “same” as on right) were measured. Configurations of red, green, blue, yellow and white (grey) inducers on light and dark grey were presented in random order under conditions of darkadaptation, rodsaturation, and daylight. Adaptation level had no significant effect. Grouping two backgrounds into a single one significantly increased the probability of no effect, suggesting mechanisms which integrate contrast at luminance borders and discount global illumination. Relative depth judgments in terms of probabilities of colored inducers to be perceived as nearer to the observer (3AFC between “left = nearer”, “right = nearer”, or “same”) show that background grouping has no effect on relative depth judgments. These are determined by inducer color and luminance contrast/polarity, producing significantly higher probabilities of brighter colors to be seen as nearer. A statistically significant effect of adaptation level is observed, where response probabilities for no effect are lowest under daylight conditions. This is consistent with observations that relative distance estimates are more accurate on a bright and clear day than on a foggy one, and more reliable on land than under water. Chevreul’s “law of contrast” for depth from color is proven to hold under conditions where local geometric cues to depth are unavailable. [Financial support: CNRS-PICS-05971.]

TALKS: EEG AND ELECTROPHYSIOLOGY

◆ **ERPs dissociate semantic and syntactic processing in scenes**

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In sentence processing, semantic and syntactic violations elicit differential brain responses in ERP recordings: An N400 has been associated with issues of semantic content, while a P600 marks syntactic structure. Does the brain register similar distinctions in scene perception? To test this, participants viewed “semantic inconsistencies” created by including objects that are incongruent with a scene’s meaning like a fire-hydrant in the kitchen. They also viewed “syntactic inconsistencies” in which an object violated structural rules, like a fork misplaced on the kitchen chair. Compared to consistent controls, semantic inconsistencies produced negative deflections similar to the “N390/N400 scene congruity effect” (Ganis

and Kutas, 2003; Mudrik, Lamy, and Deouell, 2010). In addition, we observed a late positivity for our syntactic inconsistencies, which might resemble the P600 found for syntax manipulations in sentence processing. Interestingly, extreme syntax violations such as a floating toast, showed an initial increase in attentional deployment, but failed to produce the late positivity we observed for more modestly mislocated objects. We therefore conclude that (1) different neural populations are active during the semantic and syntactic processing of objects in scenes and (2) impossible placements of objects may be categorically different from the syntactically inconsistent placements that produce a P600.

◆ **Fine-grained face discrimination and categorical face perception as evidenced by steady-state visual evoked potentials**

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Steady-state visual evoked potentials (SSVEP) can be used to rapidly and objectively measure individual face discrimination (Rossion and Boremanse, 2011 *Journal of Vision*). Here we extended this observation to fine-grained discrimination of morphed faces using an “event-related” SSVEP design. We recorded 128-channel EEG in 10 adult observers presented with 40-s sequences of faces flickering at 6Hz (sinusoidal contrast modulation). Each sequence was made of 4 repetitions of an identical face (A) followed by a morphed face (B) whose difference from the original face (A) within each sequence ranged from 0% (same identity) to 100% (different identity), in 10% steps. In line with the introduction of morphed faces at fixed intervals (AAAAB = every 4 stimuli, or 6Hz/5 = 1.2Hz), we found an enhancement of the signal-to-noise ratio (SNR) with increasing distance between the original and the morphed faces at exactly 1.2Hz and its harmonics (2 F = 2.4Hz; 3 F = 3.6Hz...). Categorical perception was revealed by a sharp SNR increase at these frequencies around the perceptual boundary (50%), mainly at right occipito-temporal channels. Event-related SSVEP designs are therefore particularly useful to examine fine-grained face discrimination and categorical face perception thresholds.

◆ **Association of pre-stimulus brain activity and perceptual organization on multiple temporal scales**

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We studied the dynamics of visual perceptual organization while recording electrical brain activity (EEG) of human observers. Observers perceived grouping of multistable dot lattices into strips and reported their orientation: the probability that one of several possible orientations prevailed at a time, followed a quantitative, law of proximity. Within trials, the power of pre-stimulus alpha activity in EEG predicted observers' orientation bias: their tendency to report vertical orientations more often than horizontal. The predictions were most reliable in the trials where the reported groupings were inconsistent with dot proximity. Between two successive trials, the probability that the same orientation was reported (“response duplets”) was higher than chance for horizontal orientations, and in this case pre-stimulus alpha power was higher than for vertical duplets. Over an entire experimental session, orientation bias steadily decreased while observers' grouping sensitivity and pre-stimulus alpha power increased. Consistent with this observation, pre-stimulus alpha power predicted orientation in single trials and duplets only in the initial part of the session. These results indicate that the dynamics of perceptual organization is governed by lasting states of the visual system and perceptual learning.

◆ **Correlated variability in laminar cortical circuits**

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The amount of information encoded by cortical circuits depends critically on the capacity of nearby neurons to exhibit correlations in responses. Despite the fact that strong trial-by-trial correlated variability in response strength has been reported in many cortical areas, recent evidence suggests that neuronal correlations are much lower than previously thought. However, the responses of cortical neurons are known to depend on their network environment, such as cortical layer. For example, in primary visual cortex (V1), the granular layer receives feedforward thalamic inputs. Subsequently, neuronal impulses from the granular layer are transmitted to neurons in supragranular layers and then infragranular layers; both layers constitute outputs of V1. We reasoned that one important distinction between cortical networks in the middle and superficial/deep layers is the spatial spread of intracortical connections. In the granular layers, where neurons receive geniculate input, the spatial spread of connections is

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small, whereas in supragranular and infragranular layers neurons receive recurrent input from larger distances (up to several mm) via horizontal and feedback circuitry. Therefore, we revisited the issue of correlated variability in V1 circuits by using laminar probes (16 contacts with a diameter of $25\mu\text{m}$ and an inter-contact distance of $100\mu\text{m}$) to record single-units from two monkeys during a fixation task. Cortical layers were identified by measuring the evoked-response potentials (ERP) and computing the current-source density to locate a sink-driven inversion in the amplitude of the ERP. We examined the laminar dependence of correlated variability, and measured spike count correlations by using multi-contact laminar probes. We found that correlations between neurons depend strongly on local network context. For our population of 327 pairs, we found that correlated variability in the supragranular layers was 0.29 ± 0.03 , similar to the values previously reported in V1. However, in the granular layer, correlation values were exceedingly low 0.03 ± 0.01 . In infragranular layers, correlated variability was high again 0.24 ± 0.03 . Cells in granular layer, which have only local projections to other layers within V1, encode incoming stimuli optimally by exhibiting extremely low correlated variability. In contrast, output layers sending projections to other cortical and subcortical areas encode information suboptimally by exhibiting large correlations. These results argue that correlations are generated within recurrent circuits, and that populations in different cortical layers play different roles in network computations.

◆ **MEG Beta band activity discriminates perceptual form and motion binding**

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Scalp recordings of electrophysiological oscillations in behaving humans reveals activity in different frequency bands thought to play functional roles in perceptual, motor and cognitive processes. We conducted a MEG study with a protocol well designed to probe the hypothetical roles of Gamma and Beta band activity in perceptual form/motion binding. Briefly, we employed an ambiguous visual moving stimulus perceived either as a whole shape moving along a Lissajou's figure (bound percept) or as independent bars oscillating along horizontal and vertical trajectory (unbound percept). Participants were to report their bound, unbound or unclassified percept after each trial. Importantly, by randomizing the position of color coded responses, thus imposing a remapping of the motor response on each trial, our protocol avoids motor preparation that could contaminate the data. We report that bilateral parietal oscillations in the Beta range (15–25 Hz) discriminate perceptual states at the individual level. Moreover, significant trial-by-trial classification of Beta band activity suggests it provides a marker of perceptual states, uncontaminated by motor preparation. In contrast, activity in the Gamma band (40–80 Hz), although significantly higher during visual stimulation than during base line, does not distinguish perceptual states. Altogether our results suggest that Beta activity plays a functional role in perceptual integration of motion and shape within and across both hemispheres. In line with recent proposals, our findings support the view that Beta activity serves to facilitate the long-range communication between distinct brain regions specialized in motion and form processing.

◆ **Eccentricity-dependent variations of the N2p in target detection**

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In ERP studies, the N2p, a negativity occurring around 200 to 300 ms after stimulus onset on posterior electrode sites, shows sensitivity to target eccentricity: foveal targets elicit larger N2p amplitudes than peripheral targets (N2p eccentricity effect). We were interested in (1) whether the N2p eccentricity effect is task-specific and compared the N2p in texture segmentation with visual search, and (2) we investigated whether the N2p eccentricity effect is only observable in target-present trials or also in target-absent trials. We also examined the role of (3) eccentricity-dependent variations in target detection difficulty (foveal vs peripheral advantage) and (4) cortical magnification. Our results suggest that the N2p eccentricity effect is (1) not task-specific, (2) shows up only in target-present trials, and can neither be due (3) to variations in detection difficulty nor (4) to cortical magnification. We conclude that the N2p might be an indicator for the existence of a foveal vs peripheral subsystem in target detection processes.

TALKS: HAPTICS

◆ **Decoding visual objects in early somatosensory cortex**

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Neurons, even in the earliest sensory areas of cortex, are subject to a great deal of contextual influences from both within and across modality connections. In the present work we investigated whether the earliest regions of somatosensory cortex (S1 and S2) would contain content-specific information about visual object categories. We reasoned that this might be possible due to the associative links formed through experience that link different sensory aspects of a given object. Participants were presented with visual images of different object categories in a block design fMRI experiment. Multivariate pattern analysis (MVPA) revealed reliable decoding of visual object category in bilateral S1 (ie post-central gyri) and right S2. In addition, a whole-brain searchlight decoding analysis revealed several areas in the parietal lobe that could mediate the observed context effects between vision and somatosensation. These results demonstrate that even the first cortical stages of somato-sensory processing carry information about the category of visually presented objects.

◆ **Bimanual integration of curvature**

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When holding a basketball or a volleyball, we can not only see, but also feel which one we are holding in our hands, due to a difference in diameter and curvature. So far, the haptic integration of distance and curvature information between two hands has received little attention. In experiment 1, distance discrimination thresholds were determined for unimanual and bimanual exploration of flat surfaces. In experiment 2, curvature was added. In the unimanual condition, subjects were asked to indicate whether the distance between a curved surface and the midsagittal plane was larger or smaller than the corresponding radius of the curved surface. In the bimanual condition, subjects were asked to indicate whether the distance between two curved surfaces was larger or smaller than the corresponding diameter of the curved surfaces. We found that there was no significant difference between unimanual or bimanual distance discrimination thresholds for flat surfaces. In contrast, bimanual exploration of curved surfaces results in lower discrimination thresholds than unimanual exploration. We conclude that haptic perception of distance is not integrated in bimanual exploration, whereas haptic perception of curvature is. [This work has been partially supported by the European Commission with the Collaborative Project no. 248587, "THE Hand Embodied", within the FP7-ICT-2009-4-2-1 program "Cognitive Systems and Robotics".]

◆ **The effect of compliance on haptic volume perception**

W M Bergmann Tiest, K Bogale Sirna, A M L Kappers (Helmholtz Institute, Utrecht University, Netherlands; e-mail: W.M.BergmannTiest@uu.nl)

In perception, size judgments may often be influenced by irrelevant object features. This study investigated how object compliance affects the haptic perception of object size (volume). In a two-alternative forced-choice discrimination experiment, eight blindfolded participants were asked to select the larger of two cubes presented on stands. There were two experimental conditions: the cubes were to be either completely enclosed with the hand, or pinch-grasped between thumb and index finger. In each trial, one of the cubes was made out of hard synthetic material, whereas the other was made out of soft foam. Points of subjective equality were derived from psychometric curves. On average, a soft cube of 8.0 cm³ was perceived to be equal in volume to a hard cube of 6.4 or 6.7 cm³ for enclosure or pinch-grasp, respectively. These significant biases indicate that volume perception is influenced by material properties, in this case compliance. The biases for the two conditions were not significantly different from each other, indicating that the method of touch does not play a large role. We hypothesise that hardness as a salient feature causes an overestimation of the object's size. [This work has been supported by the European Commission with the Collaborative Project no. 248587, "THE Hand Embodied", within the FP7-ICT-2009-4-2-1 program "Cognitive Systems and Robotics".]

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◆ **The saliency of compliance in a haptic search task**

V van Polanen, W M Bergmann Tiest, A M L Kappers (Helmholtz Institute/ Utrecht University, Netherlands; e-mail: V.vanPolanen@uu.nl)

Visual search has proven to be a valid method to investigate feature saliency. Similarly, haptic search reveals efficient perception of haptic properties. In this study, the saliency of hardness and softness was investigated in a search task. In experiment 1, participants had to grasp a bundle of spheres and determine whether a hard target was present among soft spheres or vice versa. When the difference in compliance between target and distractors was small, a serial strategy was found and reaction times increased with the number of items. With a large difference in compliance, the reaction times did not depend on the number of items and a parallel strategy was found. In experiment 2, participants had to press their hand on a display filled with hard and soft spheres. In the search for a soft target the slopes of reaction times against the number of items were high, but the locations of target and distractors had a large influence on the search difficulty. With a hard target, the reaction time was independent of the number of items. This showed that weight cues did not cause the finding in experiment 1 and that both hardness and softness are salient features. [This work was supported by the European Commission with the Collaborative Project no. 248587, "THE Hand Embodied".]

◆ **Using two hands is better than one**

M A Plaisier, M O Ernst (Bielefeld University, Germany; e-mail: myrtheplaisier@gmail.com)

From multisensory studies it is known that redundant information, for instance between the haptic and visual modalities, is integrated such that the combined percept becomes more precise. We often handle and explore objects with both hands. Is information across both hands integrated as well? Note that we usually don't touch an object at the same location with both hands and it is also quite common to simultaneously touch different objects with both hands. In such a case perceptual integration would not be beneficial, because the two estimates do not necessarily have a shared source. For this reason, we may speculate that bimanual haptic information is never integrated. Instead, here we show that bimanual stiffness information is integrated such that the bimanual percept is more precise than the unimanual percepts. Furthermore, to our surprise integration did not break down by displaying visual information indicating that the two hands were touching separate objects. Clearly, visual information alone was not enough to break the assumption that both inputs had a shared source. These results show that bimanual information is combined according to maximum likelihood estimation. Consequently, there is a clear benefit of exploring an object with both hands in terms of precision of the percept.

◆ **Plastic reorganization to form dissociated networks for perceptual encoding and memory recall in congenital blindness**

L Likova (Smith-Kettlewell Eye Research Institute, USA; e-mail: lora@ski.org)

Can short-term training produce rapid reorganization of cognitive networks in the adult brain? This question was addressed by means of our novel Cognitive-Kinesthetic training method in congenital blindness. Functional MRI was run before and after one week of training in a drawing paradigm. The specific tasks were: tactile exploration/memory encoding of complex raised-line images, drawing the images based solely on tactile memory retrieval, and scribbling, each of 20s duration, separated by 20s rest intervals. After training, dissociated networks of temporal-lobe regions emerged that were typically activated exclusively either a) during perceptual encoding or b) during memory retrieval. Pre/post-training analysis revealed that the memory retrieval network had undergone dramatic plastic reorganization relative to its undifferentiated state before the training. The hippocampus which was strongly deactivated during the memory retrieval task before training reversed its sign to become strongly activated after training. Interestingly, this reversal was correlated with the emergence of the memory retrieval network extending through the inferotemporal cortex. These findings provide novel insights into the evolution of rapid experience-based functional segregation as a consequence of active spatiomotor learning involving complex memory encoding and retrieval.

TALKS: COGNITION

◆ **Explicit coding in the brain: data-driven semantic analysis of human fMRI BOLD responses with Formal Concept Analysis**

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We investigated whether semantic information about object categories can be obtained from human fMRI BOLD responses with Formal Concept Analysis (FCA), an order-theoretic approach for the analysis of semantic information, such as specialization hierarchies and parts-based codes. Unlike other analysis methods (eg hierarchical clustering), FCA does not impose inappropriate structure on the data. FCA is a mathematical formulation of the explicit coding hypothesis (Foldiak, 2009 *Current Biology* **19** R904–R906). A human subject was scanned viewing 72 gray-scale pictures of animate and inanimate objects in a target detection task. To apply FCA, we employ a hierarchical Bayesian classifier, which maps fMRI responses onto binary attributes, and these onto object labels. The connectivity matrix between attributes and labels is the formal context for FCA. FCA revealed a clear dissociation between animate and inanimate objects in a high-level visual area (inferior temporal cortex, IT), with the inanimate category including plants. The inanimate category was subdivided into plants and non-plants when we increased the number of attributes extracted from the fMRI responses. FCA also displayed organizational differences between the IT and the primary visual cortex, V1. We show that familiarity and similarity ratings are strongly correlated with the attributes computed from the fMRI signal. [Acknowledgments: this work was supported by BMBF FKZ: 01GQ1002, EC FP7-ICT grants TANGO 249858, AMARSI 248311, and DFG GI 305/4–1, DFG GZ: KA 1258/15–1 and the Max-Planck society.]

◆ **Saccades bias mental arithmetic**

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Evidence suggests that numerical quantities expressed symbolically and non-symbolically are processed by partially overlapping mechanisms. The numerosity of visual items is underestimated in the proximity of a saccadic eye movement (Binda et al, *Vision Research* 2011). Here we ask whether a similar distortion occurs for the processing of numeric symbols. Pairs of Arabic numerals (the operands) were flashed before or after a saccade; in a speeded task, subjects reported if the sum (or subtraction) was smaller than a probe digit presented 0.5s later. The percentage of ‘sum/subtraction smaller than probe’ responses was plotted against the difference between the probe and the true result of the operation, yielding psychometric curves. For operands presented just before saccades, curves were shifted left of 0, indicating that the result of the operation was systematically underestimated; judgments were unbiased for operands presented after saccades. This was observed for both sum and subtraction, and for both rightward and leftward saccades. We conclude that both symbolic and non-symbolic numerical quantities are underestimated in the proximity of saccades. A similar compression of visual space and time happens concurrently (Burr et al *TICS* 2010), suggesting that a common system processes magnitude along multiple dimensions, and may participate in visuo-motor coordination.

◆ **Experience in judging intent to harm modulates parahippocampal activity: An fMRI study with experienced CCTV operators**

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Long experience with CCTV footage may lead to the formation of strong associations between complex visual stimuli and predicted behavioural outcome in social situations. To test this idea we scanned 15 CCTV operators and 15 age and gender matched novices while watching CCTV videos of 16 seconds and asked them to report whether each clip would end in violence or not. We carried out three separate whole brain analyses to examine differences in BOLD signal between the two groups based on (1) experimentally predefined clip types, (2) participants’ judgments during the scan, and (3) visual saliency as pre-assessed using eye-tracking. All three analyses consistently identified decreases in parahippocampal activity for expert CCTV operators when compared to novices. Whilst CCTV operators’ activity in the uncus increased with years of CCTV experience, activity in the posterior parahippocampal gyrus increased with scores of perspective-taking given by all participants. Based on

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the proximity of the uncus to the amygdala and the afferent projections the posterior parahippocampal gyrus receives from visual areas, we conclude that this region may work as a link between sensory and limbic information, a link that is not as necessary after strong associations between these kinds of information are formed.

◆ **In a self-paced shape perception task, subjects are underconfident, but make efficient use of temporal resources**

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How much time does a subject devote to each trial in a self-paced shape perception thresholding task, and how is this related to the subject's decision confidence? In a forced-choice task, subjects judged the orientation of Landolt C optotypes that were presented at different sizes at, above, and below threshold. The response times were recorded, and in each trial, subjects also rated how confident they were in their decision on orientation, using a four-point ordinal scale ("unconfident", "somewhat unconfident", "somewhat confident", and "confident"). Subjects performed on average 10% better than would be predicted by their confidence ratings. Response time was longest near threshold, and shorter above and below, with stimulus size, rather than confidence, being the primary determinant. This controverts the idea that response times are monotonously related to task difficulty, and instead supports Hogarth's law (Hogarth 1975, in *Utility, Probability, and Human Decision Making*, Eds D Wendt and C Vlek, Dordrecht, Reidel), which predicts response times to be relatively small for both easy and very difficult tasks. Such a behavior is efficient, because only around threshold the additional time spend on the task will result in better performance.

◆ **Dissociating developmental trajectories of part-specific and part-relational processing in object recognition**

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We have previously found evidence for a remarkably late consolidation of configural (part-relational) relative to part-based object recognition (Jüttner, Wakui, Petters, Kaur and Davidoff, 2012 *Developmental Psychology* in press). Here we present a series of experiments that systematically confine the origin of the delayed development of part-relational processing. School children aged 7–12 and adults were tested in 3-AFC tasks to judge the correct appearance of upright and inverted presented newly learned multi-part objects that had been manipulated either in terms of individual parts or part relations. Manipulations were constrained to either categorical or metric changes of either individual parts or part relations. For categorical changes, even the youngest children were close to adult levels of performance for recognizing both changes of parts and part relations. By contrast, performance for recognizing metric changes of part relations was distinctly impaired in young children relative to that for recognizing metric changes of individual parts, and approached the latter not until 11–12 years. This distinctly retarded onset of part-relational processing was observed for both manipulations involving relative size and relative position. The results suggest a generic developmental dissociation of categorical and metric processing for part relations, but not for individual parts, in early adolescence.

◆ **Development of face-localization after extended congenital blindness**

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The ability to localize faces in complex visual scenes is important for mediating many social interactions. Evidence that very young infants prefer to look at faces over non-faces has led to the conjecture that this ability might have innate roots. However, the operational difficulties involved in obtaining reliable responses from babies have limited rigorous experimentation to track the early stages of face localization skills. We have had a unique opportunity to address this issue through our work in Project Prakash with children who gain sight late in life. Here we report results from ten newly sighted children, ranging in age from 8 to 23 years. Subjects were presented with three versions of the face-localization task in complex natural scenes. The three conditions corresponded to (1) Faces shown with bodies, (2) Full heads, and (3) Only the internal facial features in their normal configuration. We found that children showed poor face localization immediately after sight onset, favoring an empirical account of skill acquisition. Furthermore, longitudinal assessment of performance showed that bodies and external head contours were important cues over the early course of this developmental trajectory. These results

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demonstrate preserved plasticity for visual learning even late in life and, more specifically, also have implications for the mechanisms that subserve face-learning early in the developmental trajectory.

Monday

MONDAY**POSTERS: 3D PERCEPTION**◆ **Stereoacuity across the visual field: An equivalent noise analysis**

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Stereopsis is a hyperacuity in the fovea; depth differences can be distinguished that are smaller than individual photoreceptors. However, as stereoacuity declines faster than resolution acuity across the visual field, additional factors must contribute to the reduction in peripheral stereoacuity. We examine the increase in depth discrimination thresholds with distance from the fovea using an equivalent noise analysis to separate the contributions of internal noise and sampling efficiency. Observers discriminated the mean depth of patches of “dead leaves” composed of ellipses varying in size, orientation, and luminance as a function of disparity noise (0.05–13.56 min of arc) and visual field location (0–9 degrees). At low levels of disparity noise, depth discrimination thresholds were lower in the fovea than in the periphery. At higher noise levels (above 3.39 min of arc), thresholds converged and there was little difference between foveal and peripheral depth discrimination. Parameter estimation from the equivalent noise model revealed that an increase in internal noise limits peripheral depth discrimination, with no change in sampling efficiency. Sampling efficiency was uniformly low across the visual field. The results demonstrate that a loss of precision of local disparity estimates early in visual processing limits fine depth discrimination in the periphery.

◆ **The effect of variability in other objects’ sizes on the extent to which people rely on retinal image size as a cue for judging distance**

² R Sousa¹, E Brenner², J Smeets² (¹Vrije Universiteit, Netherlands; ²Vrije universiteit, Netherlands; e-mail: ritass@gmail.com)

Retinal image size can be used to judge objects’ distances because for any object one can assume that some sizes are more likely than others. Increasing the inter-trial variability in the size of otherwise identical target objects reduces the weight given to retinal image size when judging distance. We examined whether increasing the variability in the size of objects of a different colour, orientation or shape also reduces the weight given to retinal image size. Subjects indicated target cubes’ 3D positions. Retinal image size was given significantly less weight as a cue for judging the target cubes’ distances if the target cubes were interleaved with cubes of different simulated sizes, even if such cubes were always coloured or oriented differently. This was not so if the objects with different sizes were spheres rather than cubes. We also examined whether increasing the variability in the size of cubes in the surrounding reduces the weight given to retinal image size when judging distance. It does not. We conclude that variability in surrounding or dissimilar objects’ sizes has a negligible influence on the extent to which people rely on retinal image size as a cue for judging distance.

◆ **Viewing comfort and naturalness—key factors in understanding and evaluating the perception of stereoscopic images**

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Most of the research into evaluating the perception of stereoscopic 3D images tries to draw conclusions on the overall 3D quality only by analyzing the 2D quality and the depth. But experiments show that the viewing comfort and the naturalness of the scene are two other significant factors that define the 3D experience. We implemented a psycho-visual experiment in which we explored the way these two subjective factors are perceived. We recorded the oral observations made by 26 users while watching 24 stereoscopic images displayed on a 3D screen in identical conditions. Key words were extracted from the recordings and subsequently analyzed. Our results show a very different perception of comfort among participants while watching the same images. Two hypotheses were envisaged. The first and most probable is that the degree of subjectivity due to the vision characteristics and to the background of the participants is more consistent than believed. The second hypothesis is that these large differences could be due to a slight unavoidable imprecision of a test of this type. The results also revealed the presence of the cardboard effect artifact in our images and a direct influence of this artifact on the naturalness perceived was observed.

◆ **Perceiving swinging surface in depth from luminance modulation**

- 4 Y Sakano, H Ando (National Institute of Information and Communications Technology, Japan; e-mail: yuichi@nict.go.jp)

It is well known that we perceive 3D shape of an object from its shading, that is, perception of a spatial variation of surface orientation of an object can be induced by the spatial variation in luminance across the surface. In the present study, we examined whether perception of a temporal, rather than spatial, variation of surface orientation can be induced by a temporal variation in luminance of the surface. We expected this phenomenon because assuming "light-from-above" in general, a surface receives more light when it orients upward and thus the luminance becomes higher than when it orients downward. We used a stimulus composed of paired gray rectangles placed side-by-side on a dark background. The luminance was uniform within each rectangle but temporally modulated in antiphase to each other. The rectangles appeared to change in slant, ie, they appeared slanted upward when the luminance was high, while they appeared slanted in the opposite direction when the luminance was low. This swinging-in-depth phenomenon occurred even when there was only one rectangle although its impression was weaker. These results suggest that the human visual system utilizes not only spatial luminance variation but also temporal luminance changes for the computation of surface orientation.

◆ **Spatiotemporal characteristics of binocular disparity channels for very large depth**

- 5 M Sato¹, S Sunaga² (¹The University of Kitakyushu, Japan; ²Kyushu University, Japan; e-mail: msato@kitakyu-u.ac.jp)

It is well-known that an excessive disparity causes diplopia and unclear depth impression. However, we recently found that target motion facilitates stereopsis for very large depth (Sato et al, 2007 *ITE Technical Report* 31(18), 25–28). To examine the spatiotemporal characteristics of the responsible mechanism we compared contrast sensitivities between a static and a dynamic condition using one-dimensional DoG targets. The standard deviation of positive Gaussian was ranged from 0.11° to 2.3°, corresponding to 1.6–0.08 c deg⁻¹ peak spatial frequency. In the static condition two targets (one above and the other below the fixation point) were presented for 2 s and a crossed disparity was given to one target and an uncrossed disparity was given to the other. In the dynamic condition two targets oscillated horizontally in counter phase as if the observer moved side to side. The results show that sensitivity drops rapidly above 2° disparity range in the static condition while high sensitivity remains until much larger disparity range in the dynamic condition and that the highest sensitivity was obtained for the target with 0.38°–1.1° standard deviation, corresponding to 0.48–0.16 cycles deg⁻¹. It appears that a dynamic mechanism tuned to that spatial frequency range or size mediates stereopsis for large depth.

◆ **Accommodation responses to floating image**

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We have realized several types of floating displays, including a volumetric 3D display by use of a liquid-crystal varifocal lens (Suyama et al, 2000 *Japanese Journal of Applied Physics* 39 480–484), a volumetric 3D display by use of multi bifocal lenses (Sonoda et al, 2011 *Proc. SPIE* 7863 786322), and a floating LED signage by use of crossed-mirrors (Yamamoto et al, 2012 *Proceedings of SPIE* 8288 828820). One of advantages of floating 3D display is that a real image is formed in 3D space. However, most of viewers don't have experiences on viewing floating aerial images. Therefore viewers sometimes responded that they perceived an image that was pasted on the rear optical apparatus. In this research, accommodation responses for floating displays are investigated experimentally. Auto Refract-Keratometer (WAM5500; Rexam Co. Ltd) was used for experiments. Accommodation responses were measured under binocular and monocular viewing conditions for floating displays and aerial image formed by a lens. It is revealed accommodations for a floating image is more unstable than for a paper image. Furthermore, binocular viewing stabilized accommodations. Such responses were significant in floating LED signage by use of CMA because the point spread function was as large as LED pitches.

◆ **Subjective depth position of an object displayed around a frame on a stereoscopic monitor**

- 7 H Nate (Tokyo Polytechnic University, Japan; e-mail: nate@img.t-kougei.ac.jp)

I examined if subjective depth position of a target displayed on a stereoscopic monitor (21.5 inch 3D polarized monitor) changed by varying the distance between the target and the monitor's frame. I conducted three experiments in line with pairwise comparison method. All targets was displayed before the monitor. In the first experiment, the target was always displayed on the center of the monitor. I

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varied the distance between the target and the frame by varying the monitor's size (3 kinds of size). In the second experiment, the monitor's size was always same. I varied the distance between the target and the frame by varying its size (3 kinds of size). In the third experiment, the target's position on the monitor was varied (7 positions). The first and third experiment results showed that the subjective depth distance from background to the target was long when the distance between the object and the frame was close. The second experiment result showed that the subjective depth perception was not varied when the distance between the object and the frame was varied. These results indicated the subjective target's distance was not suppressed by the frame effect of the object displayed on the 2D.

◆ **Adaptation aftereffects when seeing full-body actions: Do findings from traditional 2D presentation apply to 'real-world' stereoscopic presentation?**

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Extended viewing of visual stimuli, including high-level stimuli such as faces and actions, can result in adaptation causing an aftereffect (bias) in subsequently viewed stimuli. Previously, high-level visual aftereffects have been tested under highly controlled, but unnaturalistic conditions. In this study, we investigated if adaptation to whole-body actions occurred under naturalistic viewing conditions. Participants rated the weight of boxes lifted by test actors, following adaptation to a different identity actor lifting a heavy box, lifting a light box, or standing still. Stimuli were presented under 3 different conditions: (1) life-sized stereoscopic presentation on a 5.3 x 2.4m screen, (2) life-sized presentation on a 5.3 x 2.4m screen without stereoscopic depth information, (3) smaller than life presentation on a 22in monitor without stereoscopic depth information. After adapting to an actor lifting light or heavy boxes, subsequently viewed boxes lifted by different actors were perceived as significantly heavier or lighter, respectively. Aftereffects appeared to show similar dynamics as for other high-level face and action aftereffects, and were similarly sized irrespective of the viewing condition. These results suggest that when viewing people in our daily lives, their actions generate visual aftereffects, and this influences our perception of the behaviour of other people.

◆ **The zograscope and monocular stereopsis**

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J Koenderink¹, M Wijnjes², A van Doorn² (¹KU Leuven, Belgium; ²Delft University of Technology, Netherlands; e-mail: jan.koenderink@telfort.nl)

The zograscope is an optical device designed for the viewing of single (ie, different from stereo pairs) pictures. It was widely used in the 18th century, and even in the 19th century, when binocular stereoscopes were already in widespread use. The optical principle of the zograscope is that it removes physiological depth cues as accommodation, vergence, monocular parallax and binocular disparity. Thus, it effectively removes cues that define the picture as being a flat object in near space, leaving free room for monocular stereopsis to develop. We have constructed a zograscope and have used it to compare depth reliefs for visual objects seen in photographs of sculpture and reproductions of paintings, when viewed with and without this optical device. As expected from historical reports, the zograscope has a marked influence on pictorial relief. We show and discuss empirical results.

◆ **Assessment of glassless 3D viewing on a portable game machine**

10

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We assessed the effects of playing a video game with glassless 3D viewing on a recently released portable game machine (Nintendo 3DS, Nintendo, Japan). We asked paid volunteers (university students) to play a racing game (Mario Kart 7, Nintendo, Japan; one of the best selling 3D games of the time) for 10 min, once with 2D and once with 3D viewing. The order was counterbalanced across participants. After each play, they were asked to fill in the survey form. The questionnaires were compiled on the basis of SSQ (Simulator Sickness Questionnaire: Kennedy et al, 1993 *Journal of the Institute of Image Information and Television Engineers* 203–220), VAS (Visible Analogue Scale: Japanese Society of Fatigue Science), Ohno and Ukai (2000 *Journal of the Institute of Image Information and Television Engineers* 54 887–891), and additional items for capturing positive aspects. The participants felt stronger presence with 3D, but it did not always lead to more fun. 3D viewing made game control harder, and caused more fatigue. 3D was somewhat better appreciated after playing with 2D. The results highlighted the fact that 3D viewing is not yet appreciated as a crucial entertaining factor by the majority of our participants. [Supported by JSPS Grant-in-Aid for challenging Exploratory Research (24653187) for MAT.]

◆ **Increasing the depth-of-field with lighting conditions in 3D stereoscopic displays**

- 11 C Vienne¹, L Blondé², D Doyen², P Mamassian³ (¹Technicolor / Laboratoire Psychologie de la Perception, Université Paris Descartes, France; ²Technicolor, France; ³Laboratoire Psychologie de la Perception, Université Paris Descartes, France; e-mail: cyril.vienne@technicolor.com)

One major distinction between stereoscopic and real-world conditions of observation is the uncoupling of vergence and accommodation. This situation is generally acknowledged as a potential source of visual fatigue. The focus and the vergence distances do not match because accommodation is adjusted by spatial frequencies while vergence is adjusted to binocular disparities. However, the models of cross-coupling between accommodation and vergence merely reduce the focus distance in the screen plane while the optics of the eye define a range of distances where vision remains sharp (the depth of field (DOF)). Thus, the mismatch between accommodation and vergence naturally occurs when the vergence distance exceeds the range of distances defined by the DOF. Hence, this study aims at investigating the general benefits of increasing the DOF through the decrease of pupil aperture using an illuminated surface directed toward the observer's eyes. In a first experiment, observers had to judge the 3D shape of an object located at different simulated distances. In a second, we tested the pupil size effect in a visual search task. We discuss the results regarding the triad model (accommodation, vergence and pupil) and the potential application to the creation of 3D contents as well as stereoscopic displays.

◆ **Activating the inhibitory effect of binocular rivalry to contend ghosts in 3D imagery**

- 12 L Blondé¹, C Vienne², D Doyen¹ (¹Technicolor, France; ²Technicolor / Laboratoire Psychologie de la Perception, Université Paris Descartes, France; e-mail: laurent.blonde@technicolor.com)

3D display technologies suffer from leakage of one view into the other, creating an unintended and annoying ghosting effect. This ghosting effect decreases the image quality, almost to the point of disturbing binocular fusion, or at least modifying the 3D experience. While there is no perfect 3D display technology, ghosting has to be considered and possibly concealed when presenting 3D stereoscopic content. In this paper we present a method to reduce the impact of perceived 3D ghosting by introducing a non-linear and asymmetric processing between the left and right content. This processing activates the inhibitory effect of binocular rivalry (Baker, Wallis, Georgeson and Meese, 2012 *Vision Research* **56** 1–9) and allows the visual system to suppress the regions where ghosting was generated. A 3D display characterization step was done to identify ghosting generation conditions. And a dedicated processing was applied on image pairs to reduce the visibility of ghosting, modifying saliency between views for selected local regions. The consequences of this processing have been tested with a set of observers to verify that the visibility threshold of ghosting has been improved without perceptibly affecting 3D observation.

◆ **The vision of Federico da Montefeltro**

- 13 G van Tonder¹, D Zavagno², K Sakurai³, H Ono⁴ (¹Kyoto Institute of Technology, Japan; ²Università di Milano-Bicocca, Italy; ³Tohoku Gakuin University, Japan; ⁴York University, Canada; e-mail: gvtonder@yahoo.co.uk)

The erstwhile Duke of Urbino Federico da Montefeltro (1422–1482), Warlord and patron to the painter Piero della Francesca, suffered various scars in his military career; among these a few that, already while he was still a young man, affected his visual ability. Here, we present these historical details—including portraits of the Duke at two different stages in his life—to obtain insight into his vision, that is, what his visual capabilities were, which visual cues he most relied on, and the strategies he devised to improve this residual vision. Specifically, the evidence suggests that the Duke was willing to sacrifice his facial appearance for the sake of improved vision, ie that he had his nose surgically altered to enlarge his field of view. It also served him in his role as a horse-mounted military leader, and in some aspects may have enhanced some of his depth cues beyond the capacity of a person endowed with normal vision. We finally show how Piero della Francesca, in his masterful 1465–66 profile portrait of Federico, gives us an intuitive but uncannily personal glimpse of the way in which the Duke of Urbino looked out onto the world.

◆ **Making visual sense of Piranesi's labyrinthine spaces**

- 14 A Van Doorn¹, J Koenderink², J Wagemans² (¹Delft University of Technology, IO, Netherlands; ²KU Leuven, Belgium; e-mail: a.j.vandoorn@tudelft.nl)

In 1745 Giambattista Piranesi (1720–1778) started work on a series of etchings (14 published in 1750; 16, the original 14 reworked, in 1761) known as the Prisons (Carceri d'Invenzione). The prints show very complicated spaces, prolonged viewing leading to many novel visual understandings. Detailed

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analysis shows that Piranesi purposely introduced ambiguities and inconsistencies. The Carceri were evidently meant to entertain the viewer due to the labyrinthine nature of the depicted spaces. The viewer can forever dwell in them without exhausting their power to entertain. Yet one is visually aware of something, even on a cursory view. Do different observers see the same space? Does a single observer see the same space at different viewings? Do visual observers have coherent spatial impressions at all? We approach such problems empirically. We determine depth order for many (over a thousand) point pairs. This allows us to check consistency (eg, whether a single linear order exists). The main analysis of these results focusses on the nature of inconsistencies (there are many), and the inter-observer differences.

◆ **Inferring visual attentional capture from search slopes and intercept differences**

- 15 P Skarratt¹, G Cole², A Gellatly³ (¹University of Hull, UK; ²University of Essex, UK; ³Oxford Brookes University, UK; e-mail: p.skarratt@hull.ac.uk)

A visual stimulus is said to capture attention when associated targets remain comparatively immune to increases in display size. That is, when they give rise to shallower search functions than do targets associated with other stimulus features. On that basis, we (Skarratt, Cole, and Gellatly, 2009 *Attention, Perception, and Psychophysics* **71** 964–970) reported that targets that loom towards or recede away from the observer are equivalent in attracting attention. However, looming targets elicit overall faster responses, an additive effect we attributed to motor priming. This supposition was tested in two experiments that examined perceptual accuracy for looming, receding, and static targets. We reasoned that any motoric contribution to the looming advantage would be absent when measuring accuracy. However, results showed that accuracy was consistently higher for looming than for receding targets, suggesting they do receive attentional priority. These findings indicate that attentional primacy can manifest in terms of main effects, even in the absence of search slope differences.

◆ **The role of global 3D visual processing in motion-induced-blindness**

- 16 O Rosenthal, M Davies, A Aimola Davies, G Humphreys (University of Oxford, UK; e-mail: o.rosenthal.bham@googlemail.com)

Motion-induced blindness (MIB) refers to the alternating illusory disappearance and re-appearance of local targets against a moving background. Previously Graf et al (2002 *Vision Research* **42**(25): 2731–5) showed that MIB is modulated by binocular global depth cues. We studied the effect of monocular global 3D convexity/concavity cues on MIB frequency. The MIB stimuli comprised two static targets presented on a background of coherently moving dots forming a global 3D hourglass-like structure. Critically, the two halves of the hourglass had similar 2D local properties. However, using kinetic depth and occlusion cues, one half of the hourglass was perceived as hollow and the other as convex. MIB was increased for targets located on the convex relative to the concave half, consistent with prior effects of binocular depth. Interestingly, the convexity effect was limited to the left visual field—consistent with previously reported anisotropies in global processing. Taken together, our findings suggest (1) an underlying role of global 3D processing in MIB which (2) interacts with attentional bias towards the global context of the scene, which is anisotropic in nature.

◆ **Matching dynamic views of biological motion**

- 17 I M Thornton, P Pedmanson, Z J Wootton (Dept of Psychology, Swansea University, UK; e-mail: i.m.thornton@swansea.ac.uk)

Although motion capture techniques have made 3D point-light data ubiquitous, many studies continue to explore perception in the context of fixed, 2D views. In the current work, we examine how dynamic changes of viewpoint, such as those that would be encountered by a moving observer, affect the ability to perceive human action. On each trial of our matching task, the action performed by a central target figure was also performed by one of two equidistant flankers. The observer's task was simply to make a speeded response indicating whether the target matched the left or right flanker. Actions were randomly selected from a database consisting of familiar activities, such as walking, jumping and waving. All actions were performed "in place" and looped continuously. In a series of experiments, we explored how matching was affected by systematic rotation and translation of the target in depth. Our findings indicate that a) the addition of dynamic, multiple viewpoints, via smooth rotation around the Y-axis, improves matching performance relative to a single arbitrary view; b) increasing angular offsets between target and matching flanker systematically decreased performance; c) performance was remarkably invariant to translations of the central target in depth, almost to the point of convergence.

◆ **Change blindness to 2D and 3D objects**

18 A N Gusev¹, O A Mikhaylova², I S Utochkin³, D V Zakharkin¹ (¹Psychology Dept, Moscow State University, Russian Federation; ²PiRAE, Russian Federation; ³Psychology Dept, Higher School of Economics, Moscow, Russian Federation; e-mail: denis.zakharkin@gmail.com)

In our experiment, we tested object depth effect on change blindness. We used CAVE virtual reality system for presenting stimuli for efficient simulation of 3D cues. Observers were exposed with arrays of 5 or 20 objects under flicker conditions typically inducing change blindness. They had to see which object is changing (disappearance, color change, or spatial shift) between interruptions. Objects could be presented either randomly in space, or arranged in global regular configuration. In 2D condition, sets of squares were presented in frontal plane before observers. In 3D condition, sets of binocularly simulated cubes were presented in frontal plane. Both reaction times and error rates were measured in the experiment. We found in the result that change detection performance benefits from 3D arrays as compared to 2D arrays. Although the magnitude of effect slightly varied depending on set size, change type, and regularity, the superiority of 3D over 2D objects was essentially the same for all conditions. This principal finding is in line with previously made observations that 3D cues play an important role in deployment of attention over visual scenes (Enns and Rensink, 1990 *Psychological Science* **1** 326–323; Nakayama and Silverman, 1986 *Nature* **320** 264–265).

◆ **Enhanced perception by real-time tracking and interpreting driver actions using a driving simulator**

19 M Toma (Transilvania University of Brasov, Romania; e-mail: madalina_toma_21@yahoo.com)

Driving is a complex dynamic task that has become more and more important in the human life since the invention of the car. The driver perception is a cognitive process and it represents an essential part of driving which expresses the ability to see potential problems that become hazardous or dangerous. A lot of clear indications show that novice drivers have insufficiently developed skills, and perceive hazardous situations too late, or even not at all. Therefore, they can easily cause or be involved in car accidents. A method to improve the driver's perception is to develop an intelligent system which enhances his/her perception, it reasons instead of the driver, and it gives feedback only when he makes a wrong or an adequate maneuver. Our work tries to answer a research question that is relevant in reducing the risk of car accidents: Is it possible to enhance the perception of novice drivers with an intelligent system which analyzes the driver's maneuvers, and gives visual and auditory feedback according to different traffic situations? To track the driver's actions in real time we record hands motion by processing data from a KINECT depth sensor, and gaze and head movements with an Eyelink II tracker. To assess perception of the driver we interpret the driver's actions performed in several hazardous traffic situations built in the TORCS open source driving simulator. Automatic detection of driver mistakes were detected using an artificial intelligence method and the corresponding system response consisted of automatic alerts. An enhancement of the driver's perception was observed based on our proposed method during experimental scenarios which involve hazardous or dangerous situations. Results suggest that there is significant opportunity to enhance driver perception through the use of visual and audio feedback. In addition, we observed the improved driving performance after a training time of the novice drivers involved in the experiment.

◆ **Human adults can use two different geometrical cues when reorienting in immersive virtual environments**

20 H T Chiu, K Petrini, M Nardini (University College London, UK; e-mail: k.petrini@ucl.ac.uk)

A recent study (Lee, Sovrano and Spelke, 2012 *Cognition* **123** 144–161) has shown that two-year-old children can reorient in a room using certain geometric cue (wall distances), but not others (wall lengths). Here we investigated adults' abilities to use both kinds of information. In four virtual rectangular rooms, room geometry was specified by differing wall lengths, differing wall distances, both, or neither. After locating an object in one of the four room corners and being disoriented, 17 participants had to reorient and find the corner at which the object had disappeared. Adult participants could use both wall distance and wall length information when reorienting, reporting a higher proportion of correct responses when both cues were available. Our findings indicate that adults can use geometrical cues that very young children cannot reorient in a new environment. This suggests that very early-developing mechanisms able to encode locations relative to distances to boundaries are supplemented by later-developing mechanisms processing a wider range of cues. Relating these changes to development of neuronal

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encodings of space (Wills et al, 2010 *Science* **328** 1573–1576) is an important question for further study.

◆ **A disparity energy model improved by line, edge and keypoint correspondences**

- 21 J A Martins¹, M Farrajota¹, R Lam¹, J Rodrigues¹, K Terzic¹, J Du Buf² (¹Vision Laboratory, LARSyS, University of the Algarve, Portugal; ²Univ of the Algarve, Portugal; e-mail: dubuf@ualg.pt)

Disparity energy models (DEMs) estimate local depth information on the basis of V1 complex cells. Our recent DEM (Martins et al, 2011 *ISSPIT* 261–266) employs a population code. Once the population's cells have been trained with random-dot stereograms, it is applied at all retinotopic positions in the visual field. Despite producing good results in textured regions, the model needs to be made more precise, especially at depth transitions. We therefore combine the DEM with two complementary disparity models: (1) Responses of V1 end-stopped cells are used to detect keypoints like edge junctions, line endings and points with large curvature. Responses of simple cells are used to detect orientations of the keypoints underlying line and edge structures. The annotated keypoints are then used in the left-right matching process, with a hierarchical, multi-scale tree structure. (2) Responses of simple and complex cells are used to detect line and edge events. In the left-right matching process, disparity evidence is accumulated by combining corresponding event types, polarities and their numbers. This is done by grouping cells in the multi-scale line-edge space. By combining the three models, disparity can be improved at depth transitions and in regions where the DEM is less accurate. [Projects: PEST-OE/EEI/LA0009/2011, NeFP7-ICT-2009–6 PN: 270247, RIPD/ADA/109690/2009; PhD grants SFRH-BD-44941–2008, SFRH/BD/79812/2011.]

◆ **Subthreshold contrast smoothness as a depth cue**

- 22 Y Tsushima¹, K Komine², N Hiruma² (¹University of Regensburg, Japan Broadcasting Corporation (NHK), Germany; ²Japan Broadcasting Corporation (NHK), Japan; e-mail: osakajoukouen@gmail.com)

It is well known that the luminance contrast change of a visual stimulus is one of cues to depth. However, it is unclear how the smoothness of contrast change correlates with depth perception. Here, we investigate the relationship between the contrast smoothness and depth perception. Two same-sized bars were vertically presented on the display. Both bars contained the luminance contrast difference from one side to the other (LtoR or RtoL). The contrast difference and smoothness of contrast change from one to the other were varied from trial to trial. One participant group was asked to report which bar was more tilted (Depth task), another group reported which bar was darker (Luminance task). Both tasks were conducted with monocular viewing. In general, the performance of the luminance task would be the same or better than that of the depth task because of cognitive hierarchy. However, we find that the performance of the depth task was better than that of the luminance task when the contrast smoothness was subthreshold. The present results demonstrate two suggestions. First, contrast smoothness would be useful as one of depth cues. Second, the contrast smoothness becomes a relatively effective depth cue especially when it is subthreshold.

◆ **Contour shape and perception of holes on 3D surfaces**

- 23 H Eesa¹, I S Lim¹, D Hughes¹, M Jones², B Spencer⁴ (¹Bangor University, UK; ²Swansea University, UK; e-mail: i.s.lim@bangor.ac.uk)

Convexity and concavity are powerful determinants of figure-ground segmentation; concave sides look more like a hole (background) while convex ones as a figure (Bertamini, 2006 *Perception* **35** 883–894). In most studies of figure-ground segmentation, however, 'flat' or 2D figures are used; no variance of depth within each figure. The objective of this work is to study whether the roles of convexity and concavity are still maintained with 'curved' or 3D surfaces as figures. 3D surfaces are rendered using computer graphics software. Two images of the same 3D surface (one with a convex hole projected on it, the other with a concave hole) are presented side-by-side to an observer, who is required to choose the one looking more like a hole; 85 observers participate in this experiment. No statistically significant difference is found between convex and concave holes. In the second experiment, we augment the scene with cast shadows; the shadow due to the hole is rendered to fall on the ground, which is visible through the hole. Unlike the first experiment, much more observers choose concave holes over convex ones for looking more like a hole in a statistically significant way.

◆ **Star Trek illusion demonstrates a phenomenon of depth constancy**

24 J Qian, Y Petrov (Northeastern University, USA; e-mail: qian.jie@husky.neu.edu)

Size constancy is a well-known example of perceptual stabilization accounting for the effect of viewing distance on the retinal image size. In a recent study (Qian and Petrov, 2012 *Journal of Vision* 1, 1–10) we demonstrated a similar stabilization mechanism for contrast perception and suggested that brain accounts for effects of viewing distance on various other object features in a similar way, the hypothesis that we called “general object constancy”. Here we report a new illusion of depth further supporting this hypothesis. Pairs of disks moved across the screen in a pattern of radial optic flow. A pair appeared as a small black disk floating in front of a larger white disk, the percept of depth separation created by binocular disparity. Observers were judging whether the depth separation changed in the course of the optic flow. The illusory depth change was measured with a nulling paradigm, where the disparity separation for each pair varied in the course of the optic flow. The measured depth illusion was much stronger than the accompanying size and contrast illusions. Given that horizontal disparity decreases much faster than size with viewing distance ($\sim d^2$ vs $\sim d$), this result supports the hypothesis of general object constancy.

◆ **Stereo-fusion efficiency and oculomotor stability: Effects of central and peripheral fusion locks**

25 M Wagner¹, N Schwalb¹, J Shapiro² (¹Ariel University Center, Israel, Israel; ²Hadassah College of Jerusalem, Israel; e-mail: wag.michael@gmail.com)

We studied the efficiency and oculomotor stability of stereo fusion performed with or without zero-disparity fusion locks. Twelve normal-sighted participants were trained to elicit free-fusion stereo images embedded in RDS stereo pairs. Stimuli were static Landolt-C rings (1.2 and 3.2 deg diameter), 4 direction gaps (crossed or uncrossed horizontal disparities: 8, 20, 40 arcmin), on dark screen. Bright line frames “fusion-locks” were centrally displayed on screen surface (forming inner rectangular frame 1.3 deg vertical, 2 deg horizontal, superimposed on target area), or peripherally (inner frame 10 deg vertical and 20.5 horizontal). We measured choice-reaction-times for Landolt-C gap detection (pressing one of 4 keys corresponding to Landolt-C gap directions). Inter-trial-intervals contained eye-strain-relaxing tasks. Binocular eye-movements were recorded (EyeLink II system) during trials and ITI’s. Presence of peripheral lock significantly improved target detection RT’s in all participants (6.7s), reflecting improved stereo-fusion efficiency. Without peripheral fusion lock, participants needed longer stereo-fusion periods, showed vergence drifts and binocular instability. Unlike peripheral lock, central lock impaired binocular performance and prolonged target detection (11.8 s), especially with uncrossed disparity, apparently reflecting conflicting accommodative-vergence cues. Our results support the role of remote peripheral zero-disparity images as trigger of a sustained vergence “fusion-lock” mechanism during stereopsis.

◆ **The lack of transfer-learning in laparoscopic surgery**

26 S Preuß¹, H Hecht¹, I Gockel² (¹Institute of Experimental and Cognitive Psychology, Johannes Gutenberg-University of Mainz, Germany; ²Dept of General and Abdominal Surgery, Johannes Gutenberg-University of Mainz, Germany; e-mail: hecht@uni-mainz.de)

Nowadays many routine surgeries are made laparoscopically. Typically the surgeon operates with help of a camera and two laparoscopic instruments. At least two incisions are required for “dual-port key-hole surgery”. The camera provides an image of the three-dimensional surgery site, which is viewed as a 2D image on a monitor. Newer technology is able to thread all instruments through a “single-port” that requires only one incision, having the advantage that the risk of inflammation is only half as high. In single-port surgery the two laparoscopic instruments have to be crossed, thus complicating perceptual motor action. We conducted two experiments to investigate transfer-learning between the two methods. In a cross-over design, different groups of novices started to practice with one method and then switched to the other. The single-port method was more difficult than the dual-port method. The more complex spatial mapping in the case of crossed instruments might be responsible for this effect. Also, the 2D picture might have been harder to translate into a 3D representation in the single-port case. Subjects improved with practice of a given method, but transfer learning did not take place. We currently investigate if mental practice might facilitate a change of methods.

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◆ **New insights into the Ouchi illusion**

27 T Hilano, S Fukuda, T Oshima, K Yanaka (Kanagawa Institute of Technology, Japan; e-mail: yanaka@ic.kanagawa-it.ac.jp)

The Ouchi illusion (an upper left figure on page 75 in J Ouchi, *Japanese Optical and Geometrical Art*, Dover, 1977, New York) consists of a ring and a disc which are each filled with mutually perpendicular oblong checkered patterns. This figure is perceived as if only the middle disc were floating and moving autonomously. We show some variations of this illusion, one of which consists of two rings and a disc, and another with a checkered pattern in a different direction or different inner figures. This figure is perceived as if only the inner ring were floating and moving autonomously. Furthermore, we point out that stereoscopic versions of the Ouchi illusion are less perceived as optical illusions. The Ouchi illusion may be caused only when no parallax is present in the texture of the center disc. We also make a 3D model of the Ouchi illusion in which the central disc is a little distant from the surrounding ring was created. When we look at this model from a distance, it is perceived as if it were the original. However, the amount of optical illusions becomes smaller as we approach it. This fact supports the above hypothesis.

◆ **On the 3D aperture problem of binocular motion perception**

28 M Lages, H Wang, S Heron (University of Glasgow, UK; e-mail: Martin.Lages@glasgow.ac.uk)

The 3D aperture problem occurs when an object moves behind a circular aperture in binocular view so that endpoints from an oriented line or edge remain occluded. Similar to the 2D aperture problem, perception of local velocity remains ambiguous but its solution may reveal processing characteristics of the human 3D motion system (Lages and Heron, 2010 *PLoS Comp Biol* 6(11), e1000999). Here we investigate how observers solve the 3D aperture problem. In two psychophysical experiments we used a two-screen Wheatstone configuration to display a moving line oriented at 45° (oblique) or 90° (vertical). The line moved on a trajectory in depth at a binocular viewing distance of 55cm. It was shown through a circular aperture so that line endpoints remained occluded. The slant of the line was varied across trials with orientation disparity ranging between -6 and +6°. In an open-loop matching task observers repeatedly adjusted tilt and slant of a probe to indicate perceived line motion direction. Adjustments from four observers gave comparable results but did not match geometric model predictions. We therefore combined likelihoods of velocity constraints for the left and right eye with a conjugate prior that reflects observers' knowledge of 3D motion. We also expressed (orientation) disparity as a likelihood which may be affected by a zero disparity prior. The resulting disparity estimates were used to establish the velocity constraints in a binocular viewing geometry. Best-fitting ML estimates of this Bayesian model revealed a large bias for (orientation) disparity and small noise for motion processing. This suggests that observers approximate a 3D vector normal solution but incorporate bias from disparity processing when resolving the 3D aperture problem.

◆ **Detection of linear ego-acceleration from optic flow**

29 F Festl, F Recktenwald, C Yuan, H Mallot (University of Tübingen, Inst of Neurobiology, Germany; e-mail: hanspeter.mallot@uni-tuebingen.de)

Human observers are able to estimate various ego-motion parameters from optic flow, including rotation, translational heading, time to collision (TTC), time to passage (TTP), etc. The perception of linear ego-acceleration or deceleration, ie changes of translational velocity, is less well understood. While time-to-passage experiments indicate that ego-acceleration is neglected, subjects are able to keep their (perceived) speed constant under changing conditions, indicating that some sense of ego-acceleration or velocity change must be present. In this paper, we analyze the ego-acceleration perception and its relation to geometrical parameters of the environment using simulated flights through cylindrical and conic (narrowing or widening) corridors. Theoretical analysis shows that a logarithmic ego-acceleration parameter, called the acceleration rate ρ , can be calculated from retinal acceleration measurements. This parameter is independent of the geometrical layout of the scene; if veridical ego-motion is known at some instant in time, acceleration rate allows to update ego-motion without further depth-velocity calibration. Results indicate, however, that subjects systematically confuse ego-acceleration with corridor narrowing and ego-deceleration with corridor widening, while veridically judging ego-acceleration in straight corridors. We conclude that judgments of ego-acceleration are based on first order retinal flow, and do not make use of acceleration rate or retinal acceleration.

◆ **Stereo visual cues help object motion perception during self-motion**

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Recent studies have suggested that the visual system subtracts the optic flow pattern experienced during self-motion from the projected retinal motion of the environment to recover object motion, a phenomenon called “flow parsing” (Warren and Rushton, 2007 *Journal of Vision* 7(11) 2, 1–11). In this experiment, we tested how adding stereo visual cues to help accurate depth perception of a moving object relative to the flow field affected the flow parsing process. The displays (26°x26°, 500ms) simulated an observer approaching a frontal plane that was composed of 300 randomly placed dots. A red probe dot moved vertically over this plane or over the image plane of the projection screen through a midpoint at 3° or 5° eccentricity. A horizontal component (along the world X-axis) under control of an adaptive staircase was added to the probe dot’s vertical motion to determine when the probe motion was perceived as vertical. Participants viewed the display with and without stereo visual cues. We found that with stereo visual cues, flow parsing gains were significantly higher when the probe moved over the frontal plane, but significantly lower when it moved over the screen surface. We conclude that stereo visual cues help veridical perception of object motion during self-motion. [Supported by: Hong Kong Research Grant Council, HKU 7480/10H.]

◆ **Motion from structure**

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When an observer moves while looking at a static random dot stereogram (RDS), the surfaces with different disparities appear not to be stationary in space. We call this phenomenon “Motion From Structure” (MFS). In a real static 3D scene, the distal stimulus appears stable even though the proximal stimulus actually contains a relative motion signal. So the illusory motion in an RDS may reflect the operation of a mechanism that is responsible for the apparent stability of the real world. The problem is geometrically simple and more information than needed is known to be processed by the brain. What we do not know is which of these cues are used by the visual system to solve the problem. We conducted a series of experiments in which the subjects translated their heads (45cm peak-to-peak amplitude, 0.5Hz) while adjusting the gain (target speed/head speed) of a crossed-disparity target to make the target appear stationary. The target was a square 46cm wide displayed on a 180cm x 240cm rear projection screen at 200cm. Targets had one of 4 different disparities (8, 16, 24 and 32 arcmin). Subjects also used a stick to report the perceived distance between the background and the target. Perceived depth averaged 83% of the depth specified by disparity. However, gain settings were consistently close to 50% of the gain specified by geometry. Small head movements (5cm amplitude, 0.5Hz) are sufficient to perceive MFS but subjects perceived the target as stationary for smaller gains. Removing the background did not destroy MFS but again subjects reported smaller gains. Fixation strategy (4 different fixation positions, 2 on the target moving with it, 2 on the background stationary) modifies gain settings but the pattern of gains is highly idiosyncratic between subjects. Finally dynamic RDS give qualitatively similar gain settings but the gains are more variable.

◆ **Dependence of 3D motion integration on convex/concave surface structure**

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Previous study revealed that the perception of object’s 2D motion, which is integrated from the 1D motion of straight line-segments observed from some apertures, is strongly affected by the polarity of border-ownership assigned on those moving lines (Kikuchi and Nagaoka, ACV2006), suggesting that there exists the intimate relation between motion detection and figure-ground separation mechanisms in the visual system. On the other hand, we usually view objects binocularly and perceive objects’ surface slanted in depth. Therefore it is relevant to assume that perception of global motion of 3D object is attained by the integration of motion of local 3D patches of surfaces with different slants. This study executed psychophysical experiment investigating the nature of 3D motion integration mechanism, especially focusing whether 3D convex / concave structure of the surface affects the performance of motion integration or not. We used pairs of small surface patches slanted in depth as stimuli. The patches were drawn by DRDS, aligned horizontally. In “convex condition”, two patches expressed parts of the two planes jointing in convex manner, on the other hand, in “concave condition”, two patches expressed parts of planes jointing in concave manner. Each patches moved back and forth. The motion of pair of patches was consistent with translating-rotation whose central axis is vertical. The rotation was clockwise or counter-clockwise defined with hypothetical downward gaze, displayed for 4s. The

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subjects' task was to answer the direction of rotation by 2AFC. We obtained the result that the correct rate on the convex condition was higher than the concave condition ($p < 0.05$). This result suggests that 3D version of Gestalt factor affects the 3D motion integration.

◆ **Perceived depth and stability from motion parallax natural scene movies**

- 33 K Sakurai¹, S Matsushita², H Ono³, S Yano⁴, K Susami⁵ (¹Tohoku Gakuin University, Japan; ²Ritsumeikan University, Japan; ³York University, Canada; ⁴NHK Science and Technology Research laboratories, Japan; ⁵Kinki University, Japan; e-mail: sakurai@mind.tohoku-gakuin.ac.jp)

We developed a laterally oscillating movie-camera platform and produced motion parallax natural scene movies to test whether observers perceive depth from those movies with moving their heads. The camera platform is a motor-driven device that oscillates a camera laterally and slightly rocks it in order to converge its optical axis on a certain point in depth. The video signal obtained with the camera on this device provides the identical message as an observer viewing the scene while moving his/her head from side to side. Video movies of an actual stable object (Bonsai) were made with the camera on the platform with moving laterally back and forth in 65 mm. The observers viewed the movies in the head-movement condition (with synchronizing their head movement to the camera movement) and in the head-stationary condition. In experiment 1, 16 observers reported approximately the same magnitude of apparent depth in both conditions. In experiment 2, 15 observers reported greater stability (less apparent motion) in the head-movement condition than in the head-stationary condition when they moved their heads in larger amplitude. Although the results show no clear advantage of motion parallax in seeing depth, this device could be a new natural scene 3D display system.

◆ **The effect of stereoscopic camera separation on the estimation of a right angle**

- 34 R Black, G Meyer, S Wuerger (The University of Liverpool, UK; e-mail: r.black@liv.ac.uk)

To evaluate distortions introduced in stereoscopic 3D viewing conditions, we employed a hinge stimulus (Shibata et al, 2011 *Journal of Vision* 11(8)11, 1–29) and manipulated the virtual camera separation (or interaxial distance) of a stereoscopic image with veridical shading and texture cues at a constant viewing distance and screen size. The task of the participants ($n = 20$) was to judge whether the hinge angle (30° – 110° in 10° steps) was greater than or less than 90° . The virtual camera separation was manipulated (20, 40, 60, 80, 100 mm) resulting in retinal disparities ranging from 0.358° to 1.432° . All 25 stimulus configurations (5 hinge angles x 5 camera separation) were randomly interleaved. Object size (15cm^2), screen size (58cm screen diagonal) and viewing distance were kept constant. From the psychometric functions for each camera separation, the point of subjective equality (PSE, the angle which is perceived as 90°) and the slope were derived. We report two results: (1) the perceived hinge angle becomes more acute with an increase in camera separation; (2) the sensitivity in discriminating between different hinge angles is not affected by camera separation. Implications for viewer comfort will be discussed. [RB is supported by an ESPRC CASE studentship.]

◆ **Perceived length to width relations of city squares are task and position dependent**

- 35 H T Nefs¹, A van Bilsen², S C Pont², H de Ridder², M W Wijntjes², A J van Doorn² (¹Delft University of Technology, Dept of EEMCS, Interactive Intelligence, Netherlands; ²Delft University of Technology, Dept of IDE, Human Communication Information Design, Netherlands; e-mail: h.t.nefs@tudelft.nl)

We investigated how people perceive the aspect ratio of city squares. Earlier research has focused on distance perception and 'open' spaces rather than the perceived length to width relations urban areas enclosed by buildings and filled with people, cars etc. In two experiments we measured the perceived aspect ratio of five city squares in the historic city center of Delft, the Netherlands. We also evaluated the effect of the observer's position on the square. In the first experiment participants were asked to set the aspect ratio of a small rectangle such that it matched the perceived aspect ratio of the city square. In the second experiment participants were asked to estimate the length and width of the city square separately. In the first experiment we found that the perceived aspect ratio was in general lower than the physical aspect ratio. However, in the second experiment, we found that the calculated ratios were close to veridical except for the most elongated city square. Thus, although indirect measurements are nearly veridical, the perceived aspect ratio is an underestimation of the physical aspect ratio when measured in a direct way. Moreover, the perceived aspect ratio also depends on the location of the observer.

◆ **Non-uniform image blur and perceptual transparency**

36 H Eesa¹, I S Lim¹, D Hughes¹, M Jones², B Spencer⁴ (¹Bangor University, UK; ²Swansea University, UK; e-mail: i.s.lim@bangor.ac.uk)

Perceptual transparency needs the visual construction of two distinct surfaces from a single pattern of light intensities: a partially transmissive surface and an underlying opaque surface. The visual system takes the presence of blur as an image cue in assigning transmittance to partially transmissive surfaces (eg, translucent materials) (Singh et al, 2002 *Perception* **31** 531–552). Owing to depth-of-focus limitations in the eye, however, the visual system also uses image blur as depth cue (eg, the background detail is blurred) (Mather et al, 2002 *Perception* **31** 1211–1219). The objective of this study is to identify the components of image blur that contribute to transparency cue, but not depth cue. Our hypothesis is that randomly non-uniform blur emulates the light scattering effect of a translucent layer better than the uniform image blur used in (Singh et al, 2002 *Perception* **31** 531–552). Each of 90 observers is presented with a pair of images of a translucent layer enclosing an underlying opaque layer; one of the images is created with the randomly non-uniform blur, the other with the uniform blur. In a statistically significant manner, the majority of observers choose the randomly non-uniform blur for looking more like a translucent layer.

◆ **Three-dimensional effects of “completion by folding”**

37 D Bressanelli¹, E Giora², S Gori³ (¹Dept of Philosophy, Education and Psychology, University of Verona, Italy; ²Dept of Psychology, University of Milano-Bicocca, Italy; ³Dept of General Psychology, University of Padua, Italy; e-mail: daniela.bressanelli@gmail.com)

Elementary lines drawings can be interpreted by the visual system as representing complex 3D objects. A crucial role is there played by amodal completion, which leads to perceive planar forms as the borders of unified solids. “Completion by folding” (Massironi and Bressanelli, 2002 *Acta Psychologica* **110**(1), 35–61) is a representative case of those perceptual effects. This phenomenon consists of a pattern composed by two polygons, separated by a line or a third polygon, which are perceived as a lamina folded across a bar. In the present research the illusory depth effect occurring in this pattern is investigated. The distance between the two polygons, seen as the two arms of a unique lamina, was manipulated to test its influence on perceiving depth. The stimuli were stereoscopically presented and the binocular disparity value was taken as a direct measure of the perceived depth. Observers had to adjust the arm perceived behind the bar until it appeared to be coplanar to the arm perceived in front of the bar. Results showed that the perceptual depth increased with the distance between the two arms, until they were not seen as portions of the same laminar folded figure anymore.

◆ **Human discrimination of depth of field in stereo and non-stereo photographs**

38 T Zhang¹, H Nefs¹, I Heynderickx² (¹Delft University of Technology, Netherlands; ²Philips Research Laboratories and Delft University of Technology, Netherlands; e-mail: xixiztt@gmail.com)

Previous research has focused on blur discrimination in artificial stimuli and natural photographs. The discrimination of depth of field (DOF), however, has received less attention. DOF is defined as the distance range in depth that is perceived to be sharp in a photograph. In this case blur is related to distance and many levels of blur are simultaneously present, therefore it is unclear what the discrimination thresholds of DOF are. We measured the discrimination threshold of DOF in natural images using a 2AFC-task. Ten participants were asked to observe two images and select the one with larger DOF. Three factors were manipulated in the experiment, namely: (1) stereo and non-stereo stimuli, (2) scene content, and (3) scale of the scene. First, we found that the thresholds for deep DOF were higher than those for shallow ones. Second, there was no significant difference in threshold between stereo and non-stereo images. Third, scene content did not significantly affect threshold. Finally, the threshold decreased when the scale of scene increased. We conclude that DOF discrimination does not depend only on the distance range that is sharp but also the distance range that is blurred in the image.

◆ **The influence of shape complexity in visual depth perception of CAD models**

39 F Gîrbacia, A Beraru, D Talaba (University Transilvania from Brasov, Romania; e-mail: florinstelian@gmail.com)

Real perception of dimensions in Computer Aided Design (CAD) related activities plays an important role in the decision-making process of a design solution. While the geometrical database is 3D since long time, the user interaction within the software has not significantly changed. We have conducted two experiments to measure and record the depth value estimation of several CAD models with different

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shape complexity using traditional desktop workspace and an immersive 3D Holo-CAVE system (the first experiment) and to assert the variation of stereopsis depth perception (the second experiment). In the first experiment the complex shape objects depth was underestimated while simple objects depth was estimated more accurately. Another interesting result was that the estimated depth accuracy suffered a significant increase with the depth size that has to be perceived. The results of the second experiment show that the users presented more accurate stereopsis when the disparity value is small, while increasing the disparity value leads to more imprecise stereopsis. The conducted experimental study illustrates that the use of immersive stereoscopic visualization is considerably useful during Computer Aided Design related activities, enhancing the realism of virtual environments and objects. [Supported by SOP HRD European Social Fund and Romanian Government under contract POSDRU/89/1.5/S/59323.]

◆ **The effect of blur on interocular suppression of luminance-modulated and contrast-modulated stimuli**

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Suppression is a binocular condition that elicits repression of the visual field invoked by dissimilar inputs received by each eye. Anisometropia achieves this dissimilarity with different refractive errors. Depth and extent of suppression were measured using a 12° radius circular stimulus split into rings. Each ring's area was doubled from the central ring. Observers matched contrast interocularly to measure the depth of suppression (DoS) in eight sectors within eight rings. Different levels of monocular dioptric blur (up to 4D) induced anisometropia. The sector being adjusted was dichoptically viewed on two head-mounted displays, the observer responding to it being a higher or lower luminance-modulation (LM) or contrast-modulation (CM) with respect to the surrounding ring, using a one-up one-down staircase. DoS is the threshold relative to baseline in each of the LM and CM conditions. Increasing induced-anisometropia revealed no local suppression scotomata within the central 12° of the binocular visual field, although a general increase in suppression depth occurred at significantly different rates of ~15% per dioptre with CM compared to ~6% with LM ($p < 0.05$). Interocular suppression across the visual field deepens with increasing induced-anisometropia. Additionally, this disruption to binocular function has a greater effect on CM than LM stimuli.

◆ **Effects of central and peripheral interaction of motion in depth on postural sway**

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Although it is known that motion in large visual field induces postural sway, how motions in depth by binocular cue with different temporal frequency in central and peripheral area interact is unknown. In this study, the effects of interaction were examined by measuring head movements induced by motion in depth. The stimuli were random-dot patterns which appear to oscillate in depth at 0.1, 0.25 or 0.5 Hz in central and peripheral area. The participants' ($N = 7$) head movements were measured by 3D magnetic motion tracker during the observation of the stimuli for 90 s in each condition. The power spectrum of the sway in anteroposterior direction showed peaks at the frequency of both central and peripheral motion in depth, and the result of motion at 0.1 and 0.5 Hz showed the power was significantly higher when the motion is displayed in peripheral than central area. These results suggest that postural sway is not induced only by central motion in depth which induces vergence eye movement, and the different effects between central and peripheral display suggest that postural sway was not induced by relative disparity between central and peripheral region itself and peripheral region has greater effect on postural sway.

◆ **Fast cyclic stimulus flashing modulates dominance duration in binocular rivalry**

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We provide a new test addressing the problems of the information processing under the situation of the binocular rivalry. In this situation, the two competing stimuli (two mutually orthogonal bars oriented relatively to the vertical line by $\pm 45^\circ$) were periodically flickering in range 125–25 flashes/s. Using the tachistoscope governed by PC, the flash duration could be changed in steps of 1 ms ranging between 4–20ms. Throughout one session (lasting 3 min), the span of the flash did not change. The next span of the flash was set randomly (17 spans were used). The subject had to press the key at the moment when the alteration of the perceived bars occurred. The factor (PCA) and MDS analysis of the registered DT

showed that the variance of the DT spans depends at least on the four common factors which explain about 70% of total amount of data variance. The loadings on the third factor, if plotted against SOA, are shown to undergo DT modulations that are periodic with a cycle of 4–5 ms, thus demonstrating that the flash duration is the relevant parameter modulating the DT. In a concluding part we discuss a tentative model.

◆ **Depth perception of texture with high-resolution 3D display**

43 T Bando, Y Sasaki (Doshisha University, Japan; e-mail: yasaki@mail.doshisha.ac.jp)

We can easily get 3D television now, but not so popular. One of the reasons why it is not so popular might be due to insufficient depth information from binocular disparity in 3D television now. Lack of detail depth perception, for example, makes the distant view planar as stage backdrop and makes unnaturalness to the scene of 3D television. Texture is important feature to consider about depth perception and studied much from the aspect “3D shape from texture” (Todd and Thaler, 2010 *Journal of Vision* 10(5):17, 1–13). On the other hand detail depth information is important to get information of texture, because many surface textures are consist of detail concavity and convexity of surface, and insufficient depth information should make texture pore. In this study, we investigated if higher resolution 3D display improve unnaturalness and put reality to the surface texture of the object in the image, using super high-resolution 3D display about six times high density compare to usual 3D television. As the results of evaluation experiment we could make it sure that sufficient depth cue of binocular disparity could give us better depth information to perceive natural surface texture and also to break away from stage backdrop scene.

◆ **Visual search in depth: cue combination during natural behaviour**

44 P G Lovell¹, M Bloj², J M Harris¹ (¹University of St Andrews, UK; ²University of Bradford, UK; e-mail: julie.harris@st-andrews.ac.uk)

Threshold studies allow us to measure the human visual system’s sensitivity to particular cues; however this does not tell us if they play a significant role in our everyday interactions. By adopting a visual search approach with naive observers, we use reaction times to explore how cues are weighted during natural behaviour. Stimuli consisted of a rendered scene, lit from above and in-front, featuring a shaded rectangular aperture. Within the aperture, circular discs floated in front of a background. Discs varied in their binocular disparity, size and grey-level (albedo). These 3 cues were scaled so that they were equally discriminable. Participants were asked to report the location of the disc with most depth. A multiple-regression analysis of reaction times and choices demonstrates that for the majority (4/5) of participants, the binocular disparity cue is the major driver of the observer’s choice of disc and of the speed of their response. When cues are matched for visibility, participants ignore the size cue and assign larger weight to the disparity over the albedo cue. With a naturalistic task, the visual system favours disparity over other depth cues, despite matched cue reliabilities. This behaviour is not accounted for by standard cue-combination models.

◆ **Implied gaze direction in Japanese Ukiyoe print: An event related fMRI study**

45 N Osaka¹, D Matsuyoshi², M Osaka² (¹Kyoto University, Japan; ²Osaka University, Japan; e-mail: nosaka@bun.kyoto-u.ac.jp)

One of the issues in the neuroaesthetics of visual art is how our brain reads the mind of portrayed people using implied eye direction (IED). Artists developed various cues for representing IED. Direct/averted gaze suggests attentional concentration while divided visual direction (DVD: both eyes are fantastically squinted) implies distraction of mind. Hokusai (Ukiyoe painter) made great progress in representing both IED and implied motion (Osaka et al, 2009 *Neuroreport* 21 264–267). However, effect of DVD on face recognition remained unsolved. Artists have tried to represent IED by direct/averted gaze while Hokusai, using DVD, succeeded to show player’s mind dynamically by changing positions of the pupils. To investigate the issue, we used a schematic illustration of a face in 3 conditions: (1) both eyes were averted, (2) DVD (each eye direction was divided: left eye to left and right eye to right), and (3) control whose pupil was not drawn (no implied gaze direction). Results of fMRI scans (11 subjects) while watching illustrations showed DVD and averted gaze significantly activated IPL and SPL, respectively, while an illustration that does not imply eye direction did not activate these areas. We conclude that parietal lobule would be a critical region for understanding IED(DVD) along with STS.

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POSTERS: COLOUR PERCEPTION

◆ Opposing effects of colorations added to humorous illustrations

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A series of works formed the basis for creating a new classification of colorations divided into reassuring and playful hues as compared to alarming and serious ones (Biasi, Bonaiuto and Giannini, 2007, in *Colore e Colorimetria: Contributi Multidisciplinari*, Vol III, A Rizzi, Florence, Centro Ed Toscano). The reassuring and playful colours are pink, orange, sky blue, pale yellow, light green and other pastel hues, while the alarming and serious colours include black, grey, purple, olive green and dark blue. A large number of humorous illustrations on various topics and published in specific journals were first collected. For each topic, three typical illustrations were then chosen and arranged in various versions: black and white; in acrylics for the alarming and serious version or for the reassuring and playful one; and a mixed version. Each version was evaluated individually by adults of both genders who then gave a humour score ranging from 0 (minimum) to 10 (maximum). It was hypothesised that humour scores would be significantly higher with the reassuring and playful colours, lower with the alarming and serious hues, and intermediate with the mixed or black-and-white versions. The results constantly confirmed the working hypotheses.

◆ Dynamic desaturation illusion

47 K Takahashi¹, S Yamada¹, F Ono², K Watanabe¹ (¹University of Tokyo, Japan; ²Yamaguchi University, Japan; e-mail: takahashi.kohske@gmail.com)

When windmill patterns (like “*”) and disks (like “o”) filled with the same color are displayed alternately, observers fail to notice that the windmill patterns are colored; they see uniformly desaturated windmill patterns and colored disks alternating. This perceptual desaturation has the following characteristics: (1) A brighter background induces stronger desaturation; the strength depends almost linearly on the luminance of the background. (2) Darker windmills produce stronger desaturation. (3) The desaturation occurs only when the corresponding pair of windmill pattern and their masking disk is in the same color. (4) The desaturation occurs only when the pair of windmill pattern and their masking disk occupy the same retinal positions. (5) The perceptual desaturation occurs rapidly (within a few second). (6) The apparent desaturation occurs almost simultaneously for all the windmill patterns presented in the visual field. Since the windmills and masks must be filled with the same color and be at the same retinal position, we conjecture that a rapid adaptation process might enhance and interact with simultaneous contrast in this strong and quick perceptual desaturation.

◆ Edges and gradients in real 3D color scenes

48 J McCann¹, A Rizzi² (¹McCann Imaging, USA; ²Dipartimento di Informatica e Comunicazione, Italy; e-mail: alessandro.rizzi@unimi.it)

Color appearance can be analyzed either in terms of an object's reflectance and scene illumination, or in terms of edges and gradients. In one, appearance should correlate with reflectance because humans discount the spectra and non-uniformity of illumination. In the other, both reflectance and illumination make equal contributions to scene radiances. Edges generate large changes in appearance, while gradient are much less visible. Experiments using painted cubes, 3D Mondrians, and real scenes measured the appearance of objects with constant reflectance in complex real-world illumination. We measured scene radiances either with a meter, or with special RAW image calibration (Vonikakis, <https://sites.google.com/site/vonikakis/research/raw>). We matched the appearances of identical surface reflectances in variable illumination. The results show that matches of appearance correlate with the spatial configuration of edges and gradients, rather than with reflectance and discounted illumination.

◆ Test of dichromatic simulation by visual search paradigm

49 S Sunaga, T Ogura, T Seno (Kyushu University, Japan; e-mail: sunaga@design.kyushu-u.ac.jp)

We investigated the validity of the dichromatic simulation (Brettel et al, 1997 *Journal of Optical Society of America A* **14** 2647–2655) with a visual search paradigm. The stimuli consisted of 13 colored disks (one target and 12 distractors) on the background of the D65 chromaticity. Two colors were assigned to 6 disks as distractor colors. First, the reaction time required to find the target was measured. The reaction times for trichromatic observers in the dichromatic simulated color stimulus task tended to be shorter than those obtained from deuteranomalous observers in an original color stimulus task. This suggests that it is necessary to increase the difficulty of the detection of the target color in the simulated

stimuli. Next, we tested a modified dichromatic simulation that incorporates a reduction of excitation purity. We obtained a quantitatively good prediction when the excitation purity was reduced by a factor of 0.36. Finally, we propose a new adaptive dichromatic simulation model based on the color difference between the simulated target color and the simulated distractor color in order to obtain a better predictor of reaction time in the visual search task for color defects.

◆ **Colour discrimination threshold determination using pseudoisochromatic test plates obtained by photographic and inkjet printing**

50 K Luse¹, M Ozolinsh¹, S Fomins² (¹University of Latvia, Latvia; ²Institute of Solid State Physics, University of Latvia, Latvia; e-mail: kaiva.luse@gmail.com)

Pseudoisochromatic test plates are widely used to diagnose the type and severity of colour vision deficiencies. The aim of the study is to determine best printing technology for creation of colour vision deficiency tests. Tests for protanopia and deuteranopia were created from perceived colour matching experiments for printed colour samples by colour deficient individuals. Calibrated EpsonStylus Pro 7800 printer for ink prints and Noritsu HD 3701 digital printer for photographic prints were used. Multispectral imagery (by tunable liquid crystal filters system CRI Nuance Vis 07) data analysis show that in case of ink prints, the measured pixel colour coordinate dispersion (along the x and y axis in the CIExy colour diagram) of equal colour arrays is smaller than in case of photographic printing. The printing quality in terms of colour dispersion for printing methods used is much higher than in case of commercially available colour vision deficiency tests. Currently most of the clinically applied colour vision deficiency tests (Ishihara, H R R) classify colour vision deficit individuals in three groups—mild, medium or strong. Tests for finer classification of colour vision deficiencies are to be created based on psychophysical experiment setup to determine threshold of colour discrimination for each individual.

◆ **Red color enhances memory performance**

51 H Kojima (Kanazawa University, Japan; e-mail: hkojima@kenroku.kanazawa-u.ac.jp)

The effect of color on cognitive task performances has been reported that red enhances performance on a detail-oriented task where blue does on creative task (Mehta and Zhu, 2009 *Science* **232** 1226–1229). We replicated the effect to the variations of tasks. Methods: Sixty-six students participated in the experiment. Participants were randomly assigned into either group of red or blue background color condition. They ran cognitive tasks, such as Memory Task, Remote Association Test, Proof-reading Task, etc. The tasks were conducted in a standard, dimly lit classroom. The stimuli and the instructions of tasks were presented in black, and projected on a screen with either background color of red or blue. The illuminance and the color coordinate of red color were 47.0 lx, (0.59, 0.37), while those of blue were 46.5 lx, (0.14, 0.06), respectively. Results: Percent correct of memory task was significantly higher in red than blue condition. The results of the other cognitive tasks showed no significant difference in behavioral performance between the two color conditions. However, “creativity points” rated to the response words in Association Test and Imagination Tests, by independent evaluators, showed consistently and significantly higher for blue condition than red.

◆ **Perceptual qualities and material classes**

52 C B Wiebel, K R Gegenfurtner, R W Fleming (Justus-Liebig Universität Giessen, Germany; e-mail: Christiane.B.Wiebel@psychol.uni-giessen.de)

In daily life we often refer to materials based on their subjective properties (softness, roughness, colour) or as belonging to a specific class (metal, wood, fabric). Here, we studied how these two representations interact and compared visual and cognitive representations of material categories. Nine subjects rated 130 images from the FLICKR material database on nine different material properties (glossiness, transparency, colourfulness, roughness, hardness, coldness, fragility, naturalness and prettiness). Additionally, 65 subjects filled out a questionnaire in which they judged six different material categories according to 42 adjectives, based on their imagination. In both studies we found a high degree of consistency between subjects. To identify the most important perceptual dimensions we applied PCA to the ratings. Interestingly, we found all the materials could be represented in a meaningful way and were systematically clustered within a 2D space. In both experiments, one axis broadly captured the properties hard versus soft, while the other axis captured transparency and roughness. This suggests a systematic relationship between abstract perceptual qualities and material class. A procrustes analysis revealed that the PCA spaces from the two experiments were highly consistent, indicating a large accordance between the visual and cognitive representation of material categories tested here.

Monday

◆ **Perceptual tone-mapping operator based on multiresolution contrast decomposition**

53 X Otazu (CVC / UAB, Spain; e-mail: xotazu@cvc.uab.es)

Tone-mapping operators (TMO) are used to display high dynamic range (HDR) images in low dynamic range (LDR) displays. Many computational and biologically inspired approaches have been used in the literature, being many of them based on multiresolution decompositions. In this work, a simple two stage model for TMO is presented. The first stage is a novel multiresolution contrast decomposition, which is inspired in a pyramidal contrast decomposition (Peli, 1990 *Journal of the Optical Society of America* 7(10), 2032–2040). This novel multiresolution decomposition represents the Michelson contrast of the image at different spatial scales. This multiresolution contrast representation, applied on the intensity channel of an opponent colour decomposition, is processed by a non-linear saturating model of V1 neurons (Albrecht et al, 2002 *Journal of Neurophysiology* 88(2) 888–913). This saturation model depends on the visual frequency, and it has been modified in order to include information from the extended Contrast Sensitivity Function (e-CSF) (Otazu et al, 2010 *Journal of Vision* 10(12) 5). A set of HDR images in Radiance RGBE format (from CIS HDR Photographic Survey and Greg Ward database) have been used to test the model, obtaining a set of LDR images. The resulting LDR images do not show the usual halo or color modification artifacts.

◆ **Spatial frequency overestimation with retinal eccentricity for isoluminant chromatic gratings**

54 M Toscani, M Valsecchi, K Gegenfurtner (University of Giessen, Germany; e-mail: toscani@uni-giessen.de)

The human visual system overestimates the perceived spatial frequency of luminance gratings in the peripheral visual field (Thorpe et al, 1987 *Journal of the Optical Society of America* 4 1606–1611). This is thought to be due to a failure to adapt the labeling of spatial-frequency channels in the periphery, where spatial pooling causes the channel peak sensitivities to shift towards lower spatial frequencies (Thorpe, 1990 *Journal of the Optical Society of America* 7 286–296). This shift is more pronounced for isoluminant chromatic stimuli than for luminance stimuli (Mullen et al, 2005 *Perception* 34 951–959). Therefore the peripheral overestimation of spatial frequency should increase more steeply with eccentricity for color than for luminance gratings. We asked the observers to adjust the spatial frequency of luminance and isoluminant chromatic peripheral gratings to match a foveally presented grating. Observers were tested at 2, 4, 6 and 8 degrees of visual angle. Spatial frequency overestimation increased with eccentricity with a steeper slope for isoluminant chromatic gratings than for luminance gratings, even when the contrast of the stimuli was variable. Since real-world edges typically consist of combinations of luminance and color, this should amount to a serious calibration problem for our visual system.

◆ **Effects of chromatic (red-green) and achromatic orthogonal masks on perceived contrast of luminance targets**

55 S Clery¹, J M Harris¹, M Bloj² (¹ School of Psychology, University of St Andrews, UK; ² School of Optometry and Vision Sciences, University of Bradford, UK; e-mail: sc855@st-andrews.ac.uk)

Masking has been used to study spatial vision and how the visual system combines oriented spatial filters. The common findings are suppressive effects; but in the context of detection tasks facilitatory effects have been shown when target and mask were of similar contrast. The aim of our experiment was to investigate whether these effects are present for supra-threshold contrast perception. Participants matched the contrast of a right oblique achromatic component of a plaid to a separate right oblique achromatic grating with the same spatial properties (0.75 cpd and 4 deg diameter). The target stimuli were set to several contrast values (0, 0.04, 0.15, 0.32, 1). We used two types of left oblique masks: chromatic (low or high contrast) and achromatic (0.02, 0.04, 0.2); plus a control condition without mask. Participants were generally veridical in their match without masks. Depending on the participant, luminance and chromatic contrast showed suppressive, enhancing or no effects when compared to the baseline condition. We show that the chromatic data cannot be explained by luminance artefacts. This emphasises the individual differences in contrast perception that should be taken into account if we are to fully understand the mechanisms underlying shape-from-shading and colour-shading effects.

◆ **Gradient processing: excitatory and inhibitory interactions between achromatic and chromatic mechanisms**

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Previous studies using gratings have found inhibitory interactions (cross-masking) between the 'independent' chromatic and achromatic post-receptoral mechanisms (Switkes et al, 1988 *Journal of the Optical Society of America A* **5**(7), 1149–1162; Mullen and Losada, 1994 *Journal of the Optical Society of America A* **11**(12), 3136–3151; Chen et al, 2000 *Vision Research* **40** 789–803). Here, we investigated the interactions between the achromatic and isoluminant red-green mechanisms for gradient perception. Our (4°) gradient stimulus consisted of smooth variations in luminance and/or chromaticity over half period of a sinusoid (sine phase at the centre of stimulus) without repetition of cycles. Isoluminant points were determined for each observer ($n=3$) by heterochromatic flicker. We measured discrimination thresholds between test+pedestal and pedestal versus increased pedestal contrasts (TVC functions) for uncrossed (luminance test on luminance pedestal or chromatic test on chromatic pedestal) and crossed conditions (chromatic test on luminance pedestal or vice versa) using a 2-AFC QUEST procedure. In our experiments, the same luminance pedestal had opposite effects on the detection of a chromatic test (masking) and luminance test (facilitation). In addition to the expected cross-masking, we also found some weak cross-facilitation. Most recent models of post-receptoral interactions do not account these effects; we are currently developing candidate models for gradient perception that do.

◆ **Effect of relative luminance and chromatic contrast and contrast polarity on hyperacuity thresholds: do luminance and chromatic information independently contribute to vernier performance?**

57

B Cooper, B B Lee (Graduate Center for Vision Research, SUNY College of Optometry, USA; e-mail: bcooper@sunyopt.edu)

We have shown that luminance and chromatic channels both access mechanisms used in hyperacuity judgments (Sun et al, 2012 *Vision Research* **56** 28–37); we used grating pairs where luminance and/or chromatic contrast polarities were the same or opposite. Additionally, physiological results from macaque retinal ganglion cells were incorporated. Here we test if luminance or chromatic content contribute independently to hyperacuity judgments using grating pairs containing luminance and chromatic contrast that was varied independently with respect to both polarity and relative contrast. With luminance and chromatic contrast polarity in phase, hyperacuity thresholds with both luminance and chromatic contrast present corresponded to the lower threshold measured when the luminance or chromatic gratings were presented alone. This suggests independent access for luminance and chromatic channels to hyperacuity mechanisms. Consistent with this view, when contrast polarity of the chromatic component was reversed, luminance hyperacuity thresholds were unaffected. However, an out-of-phase luminance mask substantially elevated thresholds relying on chromatic contrast. These psychophysical data were also related to physiological measurements. The results suggest luminance signals are preferentially used as a hyperacuity cue. We interpret this as support for the idea that luminance and chromatic information is maintained independently in the afferent signal for cortical vision processing

◆ **The effect of smile and illumination color on age estimation from faces**

58

M Lucassen, T Gevers, H Dibeklioglu (University of Amsterdam, Netherlands; e-mail: h.dibeklioglu@uva.nl)

We asked participants to (1) rate the emotion type and strength of human facial expressions from still images showing persons with a neutral expression and a spontaneous smile, and (2) estimate the age of the persons. These images are shown on a calibrated LCD display and are rendered under neutral (D65) illumination and under two simulated illuminants "happy" and "sad". The latter two are constructed such that a perfectly white reflector takes on the same chromaticity and luminance as the average colors that are associated with faces showing happiness and sadness (Da Pos and Green-Armytage, 2007 *Colour, Design and Creativity* **1**(1) 2, 1–20). Both male and female persons are shown in the images, 84 in total, ranging in age from 8 to 76 years, not wearing glasses. Preliminary results, based on the data from 15 participants, show that neutral faces are most frequently categorized as "happiness", followed by "sadness" (this holds for all three illuminants). On average, estimated ages are above the actual age. Below the actual age of 40, smiling makes the estimated age higher than for the neutral face, and vice versa above the actual age of 40. This effect is even slightly amplified by the "happy" and "sad" illuminants.

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◆ **Color does not guide eye movements: Evidence from a gaze-contingent experiment**

- 59 H Trukenbrod¹, S Barthelmé², F Wichmann³, R Engbert¹ (¹University of Potsdam, Potsdam and Bernstein Center for Computational Neuroscience, Berlin, Germany; ²Technical University, Berlin and Bernstein Center for Computational Neuroscience, Berlin, Germany; ³Eberhard Karls University, Tübingen and Bernstein Center for Computational Neuroscience, Berlin, Germany; e-mail: Hans.Trukenbrod@uni-potsdam.de)

Color plays a crucial role in everyday life and supports actions like searching specific objects. Whether this results from modified eye guidance has not systematically been explored. Using natural scenes, we investigated the influence of color on eye movements in a visual search task. The availability of color information was limited to a constant area around fixation by presenting gaze-contingent stimuli. The remaining image was masked by a luminance-matched grayscale version of the scene. Across trials, we used six different mask sizes. Fixated stimuli ranged from black-and-white to fully colored images. Before each trial, participants were instructed to look for a bullseye-shaped target defined either by luminance or luminance plus color. Our results show that color information was not used to guide eye movements. Except for minor disruptions in conditions with small masks, fixation durations and saccade amplitudes did not differ across conditions. Even looking for a specific color target did not change statistical measures of eye guidance. While it is beyond question that color supports vision, our results suggest that color does not modify eye-movement control. While color might help to facilitate processes like object segmentation, oculomotor control seems to be unaffected by color information.

◆ **S-cone contribution to non-assimilative color spreading in the watercolor configuration**

- 60 M Kuroki¹, E Kimura² (¹Graduate School of Human and Social Sciences, Chiba University, Japan; ²Dept of Psychology, Faculty of Letters, Chiba University, Japan; e-mail: lapis96lazuli@yahoo.co.jp)

A colored line flanking a darker contour will appear to spread its color over the area enclosed by the line (watercolor effect). The watercolor effect has been characterized as an assimilative effect, but non-assimilative spreading has also been demonstrated with the same spatial configuration; eg, when a black inner contour is paired with a blue outer contour, yellowish spreading can be observed (Pinna and Grossberg, 2005 *Journal of the Optical Society of America* **22** 2207–2221). In investigating color spreading in the watercolor configuration, we found that the two types of color spreading could be observed simultaneously but on the opposite side of the contours. The assimilative spreading occurred in the area enclosed by the lighter contour, while the non-assimilative spreading occurred in the area enclosed by the darker contour. Furthermore, we also found that S-cone signals played a critical role in the non-assimilative spreading; the induced color generally varied along the S-cone axis in the chromaticity diagram and the magnitude of the spreading correlated with differences in S-cone contrast between the inner and outer contours. These results suggest that the interaction between luminance and S-cone signals is critical for the non-assimilative spreading, and that different visual mechanisms contribute to the assimilative and non-assimilative spreading.

◆ **Variation in the vision of a rectangular sequence, interspersed in a achromatic or monochromatic grating**

- 61 J Montalvá Colomer¹, I Tortajada Montañana¹, M Aguilar Rico² (¹Universidad Politécnica de Valencia, Spain; ²Escuela Técnica Superior de Ingeniería del Diseño, Spain; e-mail: jorgemontalva@gmail.com)

Like what happens with achromatic gratings and chromatic sequences (paper presented at the X National Optics Meeting in Zaragoza, Spain) the value of the Bezold effect on the vision of the sequence depends on the orientation of the grating. With red monochromatic grating, the difference between the vertical and horizontal orientations (higher value with the horizontal orientation) is almost constant on the order of 0.02 to 0.04 increasing the angular frequency of the grating. This behavior is different from the green or blue monochromatic gratings, although the value of the Bezold effect is still greater with the horizontal orientation. The behavior of this difference blue or green monochromatic gratings with the angular frequency of the grating is different from the red monochromatic grating. In blue gratings the difference increases (although slightly) with the angular frequency of the grating for frequencies below 2 cycles/degree (approximately), decreasing for higher frequencies. In green gratings the difference between the Bezold effect of two orientations (horizontal–vertical) also decreases with lower frequencies of 2 cycles/degree (approximately), greatly increasing (0.01 to 0.10) with higher frequencies.

◆ **Perceptual misbinding of colour in rivalrous motion stimuli**

- 62 R T Maloney¹, S K Lam¹, C W G Clifford² (¹University of Sydney, Australia; ²University of Sydney, ARC Centre of Excellence in Vision Science, Australia; e-mail: ryan.maloney@sydney.edu.au)

The correct and coherent binding of distinct visual features (colour, motion, orientation, etc) is a hallmark of normal vision. The binocular rivalry paradigm is useful for studying these interactions as it provides a situation in which conflicting images at corresponding retinal locations compete for perceptual dominance. Based on the existing evidence, it has been argued that chromatic information carried by parvocellular channels tends to promote rivalry, whereas motion signals carried predominantly by magnocellular channels tend to combine interocularly (He et al, 2005, in *Binocular Rivalry*, Eds D Alais and R Blake, Cambridge, MIT Press). Somewhat counter to this, a misbinding of isoluminant colour within rivalrous form has recently been reported, such that the dominant percept consists of colours sourced from both eyes (Hong and Shevell, 2006 *Visual Neuroscience* **23** 561–566). Investigating this effect using counter-rotating isoluminant colour gratings, we found that while stimulus motion tended to rival, colour tended to misbind: the colours of both gratings appeared to be carried in the motion of a single grating. This suggests that the determinants of rivalry are not necessarily the same for colour and motion and supports the idea that motion rivalry can occur in isolation (Alais and Parker, 2006 *Neuron* **52** 911–920).

◆ **Organic light-emitting diode monitors in vision science**

- 63 T Elze, C Taylor, P Bex (SERI, Harvard Medical School, USA; e-mail: tobias-elze@tobias-elze.de)

Organic light-emitting diode (OLED) monitors, although currently still niche products on the display market, are becoming more and more popular. While the dominant display technology, liquid crystal displays (LCDs), has been analyzed and criticized with respect to their temporal behavior, OLED devices have not yet been assessed for applicability in vision research experiments. Here, we analyze the photometric and colorimetric output of OLEDs. In contrast to LCDs, OLED monitors work without backlights and can display darker black levels. However, we found cases where the color primaries were not able to display the full luminance range of 8 bit, which may impair experiments relying on color. Moreover, we found duty cycles per frame which were substantially less than one. The resulting high amplitude frequency component at the refresh rate can be within the window of visibility of neurons in the visual system and may impair applications in visual neuroscience like single unit recordings. On the other hand, compared to LCDs, luminance transitions on OLEDs occur almost instantaneously and are independent of preceding frames. Therefore, OLEDs are considerably more suitable than LCDs for experiments that require high temporal precision. Their temporal precision is comparable to that of cathode ray tube (CRT) monitors.

◆ **Temporal discrimination of flashing colour stimuli under chromatic background**

- 64 R Stanikunas¹, A Svezgda¹, L Saveikyte², H Vaitkevicius¹, R Blummas¹, A Daugirdiene¹, V Kulbokaite¹ (¹Dept of General Psychology, Vilnius University, Lithuania; ²Dept of General Psychology, Vilnius University, Lithuania; e-mail: rytis.stanikunas@ff.vu.lt)

The temporal sensitivity of human visual system was investigated. The two separate lights which flash at different temporal intervals were presented under coloured background. The three primary LED's (red, green and blue) were used as flash lights. The background extending full visual field was illuminated by one of the primary LED's or D65 illuminant composed of three primary LED's. Our results suggest that background colour has influence on temporal discrimination threshold increasing sensitivity for some colours and reducing it for others. Also, the background colour induces change in flash colour perception for some combinations of background and stimuli colour. It seems likely, that the temporal discrimination process has three stages. At the first stage stimuli are perceived as flashing together. At the second stage flashes are perceived as different in time, but it is not possible to tell which stimulus flashes first. At the third stage it is clearly visible which stimulus flashed first. [Supported by the Research Council of Lithuania MIP-23/2010 and MIP-013/2012.]

Monday

POSTERS: ILLUSIONS

◆ The Pot Lid illusion in parallel perspective

65 S Mastandrea¹, S Hammad², J M Kennedy² (¹University of Rome, Roma Tre, Italy; ²University of Toronto, Scarborough, Canada; e-mail: s.mastandrea@uniroma3.it)

One of us has frequently chosen a pot lid that was too big. Hypothesizing the error was a problem with foreshortening, we depicted a cylinder in parallel perspective, tilted 30°, with the top circle foreshortened to a 2D ellipse. Parallel projection provides foreshortening without convergence. Observers judged which of two 2D ellipses was identical to the one depicting the cylinder's top. One had the same dimensions as the ellipse depicting the cylinder top, 40 mm wide and 15 mm tall, and the other one was bigger, 41 x 18. The observers chose the bigger ellipse. An ellipse depicting a cylinder's top may look bigger because of crosstalk from perceptual information for a circle in perspective. This information for a tilted 3D surface "biases" perception—merely biasing the 2D ellipse towards the circle. The 2D ellipse's apparent eccentricity is simply lessened—it does not go all the way to a perfect circle. With respect to our original errors with real pot lids, if depicting ellipses can be biased towards circles then surely really circular pot lids can be similarly biased towards ellipses, when the lids are viewed highly tilted.

◆ Modification of each color component and shaking to enhance optimized Fraser-Wilcox Illusions

66 K Yanaka¹, T Hilano¹, A Kitaoka² (¹Kanagawa Institute of Technology, Japan; ²Ritsumeikan University, Japan; e-mail: akitaoka@lt.ritsumei.ac.jp)

We describe a new method to enhance Kitaoka's optimized Fraser-Wilcox optical illusions other than Type V by using only red and blue color components and shaking the image. The Fraser-Wilcox illusion is very interesting because it causes illusory motion although it is actually perfectly stationary. The amount of motion is considerably increased when a soft or a hard copy of an illusory image classified as Type V by Kitaoka is shaken at the frequency of several Hz (Yanaka et al, 2011 *Perception* **40** ECVF Supplement). However, as optical illusions other than this one are cannot be strengthened by shaking, we have introduced a new technique. When the original illusory image was already colored like Kitaoka's 'Rotating snakes', the green component was completely removed, and the gray levels of the red and blue component were corrected, respectively. When the original illusory image is monochrome, the image was colored by using tone curves of red and blue components although the output of the green component is always set to zero, depending on the level of grayness of the original image. When the modified images were shaken, strong illusory motion was observed. This technique can be applied to not only "Type V" but also almost all types of Kitaoka's optimized Fraser-Wilcox optical illusions.

◆ Okuma illusion: a new illusion of leaning

67 T Yasuda¹, T Ueda², K Shiina² (¹Faculty of Science and Engineering, Waseda University, Japan; ²Faculty of Education and Integrated Arts and Sciences, Waseda University, Japan; e-mail: shiina@waseda.jp)

A new illusion about tilt perception of objects is reported. Physically, the objects in a rotated picture should tilt the same degree as the picture itself. Our finding is, however, that the tilts of objects in a rotated photograph are perceived differently. The picture used in this illusion contains a statue and a tower. When the picture is tilted, we perceive that the tower follows the tilting of the picture, while the statue doesn't. We tested several objects and found that this phenomenon was salient when an element in the picture had non-geometric shape. The same inclination effects were observed when the statue was replaced by another statue or an animal, whereas the effect was diminished when the statue was replaced by a building. This illusion is possibly caused by the difficulty of judging the centerline of the object. If the centerline of an object is easy to estimate, as in the case of a tower or a building, our perception of tilt will be correct. If an object has a non-geometric shape, the detection of centerline will be difficult, making our perception of tilt harder.

◆ The reverse Café wall illusion

68 M Takashima¹, K Shiina², T Fujii³, K Shinohara⁴ (¹Iwaki Meisei University, Japan; ²Tsukuba University, Japan; ³Keiai University, Japan; ⁴Dokkyo University, Japan; e-mail: midori.takashima@iwakimu.ac.jp)

When the mortar lines in Café Wall Illusion were wider, the perceived direction of tilt of the mortar lines is reversed (Earle and Maskell, 1993 *Perception* **22** 383–390). However, they did not mention the parameter in detail. We studied how the width of mortar lines affects the direction of tilt in Café

Wall Illusion, Munsterberg Illusion, and 'reverse Café Wall illusion' (Kitaoka, Pinna and Brelstaff, 2004 *Perception* **33** 11–20). As our results, when gray mortar line in Café Wall Illusion was a little wider we clearly perceived the reverse illusion, but when the mortar line was further wider the illusion decreased. When black mortar line in Munsterberg illusion was wider, the reverse illusion was apparent but weak. When the mortar line in 'reverse Café Wall illusion' was wider, perceptual direction of line tilt could be further reversed, that is in the orthodox direction. Some participants did see reversal of the reverse Café wall illusion but some did not. Our results cast the caution for the theories and models to explain these illusions.

◆ **Anomalous motion illusions and retinal visual reset**

69 M Idesawa (UEC Communication Museum, UEC Tokyo: The University of Electro-Communications, Japan; e-mail: idesawa@is.uec.ac.jp)

Anomalous motion illusions observed in still figures (Fraser and Wilcox, 1979 *Nature* **281** 565–566) and in swinging figures (Ouchi illusion family) are the fascinating topics in vision study. In the former study (Idesawa, 2010 *Optical Review* **17** 557–561; Idesawa, 2010 *Perception* **40** ECVF Abstract Supplement 172), the author had proposed the model for explaining them by postulating the filtering process (sharpening with lateral inhibition and blurring in image slip) and the visual reset (periodical zero level renewing); then, simulated them successfully. The filtering process can be expected easily from the features of integration, delay and lateral inhibition in the retinal cells. For the visual reset, the horizontal cells, in which short term zero levels in certain areas may be generated by spatiotemporal integration and fed back with delay, may play important role. The author has examined the rate of periodical reset by detecting the velocity giving stationary perception in the moving grating patterns; then found that it was varied with the environmental illumination level (for instance, 25lx:~20Hz, 500lx:~35Hz, 5000lx:~40Hz). It is inferred that the feedback delay has some relations with the period of visual reset and the synchronization may take place often with micro-saccade, blinking and/or cortical level reset.

◆ **The Fraser-Wilcox illusion and its extension**

70 A Kitaoka (Ritsumeikan University, Japan; e-mail: akitaoka@lt.ritsumei.ac.jp)

The Fraser-Wilcox illusion (Fraser and Wilcox, 1979 *Nature* **281** 565–566) is one of anomalous motion illusions displayed in a stationary image. Here I review studies of the Fraser-Wilcox illusion and its extension including "Rotating snakes" (<http://www.ritsumei.ac.jp/~akitaoka/index-e.html>). Perceptual dimorphism featuring the Fraser-Wilcox illusion is explained by the interaction between two coexisting illusions. A new effect, "darkening disambiguation" of the Fraser-Wilcox illusion, is proposed. Moreover, the "optimized" Fraser-Wilcox illusions and the role of color in these illusions (Kitaoka, 2006, Paper presented for the 9th L'ORÉAL Art and Science of Color Prize) are discussed.

◆ **The relative motion aftereffect in the Enigma illusion**

71 E Tomimatsu, H Ito (Kyushu University, Japan; e-mail: tomimatsu@kyudai.jp)

Enigma is an artwork created by Isia Leviant, in which illusory motion is seen in rings placed on a radial pattern consisting of spokes. We tested whether a relative motion aftereffect could be reflected in the illusory stream on the ring. Participants viewed the center of a physically rotating Enigma stimulus as adaptation. We found that when spoke rotation was stopped, an illusory stream on the ring was seen mainly in the same direction as that of the preceding physical spoke rotation. In a second experiment, we replaced the gray ring with a ring filled by random-dots. To investigate the effect of the relative motion adaptation in the Enigma illusion, we rotated the random-dots and the spokes independently in the adaptation period. When a static Enigma image was presented after viewing the ring and spokes rotating in opposite directions, an illusory stream on the ring was vividly seen in the same direction as that of the preceding spoke rotation. The results suggest that relative motion detectors with receptive fields corresponding to the ring area produce the illusory motion stream in the Enigma illusion.

◆ **The Spider illusion**

72 J Geier¹, M Hudak² (¹Stereo Vision Ltd, Hungary; ²Budapest University of Technology and Economics, Dept of Cognitive Science, HAS-BME Research Group, Hungary; e-mail: mhudak@cogsci.bme.hu)

We show a dynamic illusion. A section of an Ehrenstein pattern (figure 1 in Pinna B, Spillmann L, Ehrenstein W H, 2002, "Scintillating lustre and brightness induced by radial lines" *Perception* **31**(1) 5–16) is moved up and down taking 1 cm long steps in a 5 cm wide, 20 cm long vertical path. This way, an illusion is obtained, which is similar to a spider clambering up along the two vertical edges of

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the path, while its legs are moving downwards. It can also be described as if two half cogwheels were rotating in opposite directions along the edges. When the figure is moved downwards, the 'spider legs' or 'cogs' are seen as if they were moving upwards. The illusion is even more effective when Stubb's figure is used (figure 6 in Gori S, Stubbs D A, 2006, "A new set of illusions-the Dynamic Luminance-Gradient Illusion and the Breathing Light Illusion" *Perception* **35**(11) 1573–1577). The possible explanation is identical with that of the phi-effect: if an endpoint of a horizontal 'spider leg' abruptly jumps to the previous location of the corresponding endpoint of an oblique one, then it is perceived that the horizontal line has become oblique.

◆ **Illusory motion and motion capture in terms of oblique components**

73 M Ichikawa¹, Y Masakura² (¹Chiba University, Japan; ²Tokyo University of Technology, Japan; e-mail: ichikawa@L.chiba-u.ac.jp)

When viewing the concentric circles, which consist of oblique components, the observers see an illusory rotation of the circles by changing the viewing distance (Pinna and Brelstaff, 2000 *Vision Research* **40** 2091–2096). If several dots were superimposed on the concentric circles, they will see the illusory rotation not only for the circles, but also for the dots (Ichikawa et al, 2006 *Perception* **35** 933–946). This illusory rotation of the dots, which have no means for generating illusory motion themselves, is based on "motion capture". In this study, we examined how the amount of dots (ranging from 0 to 32) and proximity among them (ranging from 1mm to 110mm on a paper) affect the illusory rotation for the circles (approximately 150mm in diameter) and motion capture for the dots. Although the illusory rotation for the circles declined with the increment of dots, that for the dots increased with the increment of dots. The proximity among the dots has no consistent effect for motion capture, while it enhanced the illusory rotation for the circles. These results suggest that motion capture is caused by the leakage of motion signal from the oblique components, and accumulation of the motion signal at each superimposed element.

◆ **The influence of motion integration on shifts in perceived position**

74 P J Kohler, C E P Cavanagh, P U Tse (Dartmouth College, Denmark; e-mail: peter.j.kohler.gr@dartmouth.edu)

The perceived position of a briefly flashed stimulus can be shifted in the direction of nearby motion (Whitney and Cavanagh, 2000 *Nature Neuroscience* **3**(9), 954–959). We used a horizontally translating diamond stimulus (Lorenceau and Shiffrar, 1992 *Vision Research* **32**(2), 263–273) to examine how different interpretations of ambiguous local motion affect the position shift. Two dots were flashed as motion direction reversed, such that the dots appeared shifted in opposite directions. Subjects viewed the stimuli while maintaining central fixation, and adjusted comparison stimuli to report perceived dot positions. When the diamond was presented behind occluders producing a vertical global motion percept, the dot position shift was primarily vertical. When the diamond was presented without occluders, the global motion was horizontal, but surprisingly, the dots were shifted both horizontally and vertically. In both cases the local diamond motion at the dot positions was identical. Position shifts can also occur in the absence of physical motion signals (Watanabe, Nijhawan and Shimojo, 2002 *Vision Research* **42** 2645–2650; Shim and Cavanagh, 2004 *Vision Research* **44** 2393–2401). Here physical motion is present but ambiguous, and we find that position shifts are influenced, but not completely determined, by the integration of physical local motion into global percepts.

◆ **On visible persistence: inter and cross modal measurements in transient random dot stimuli**

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Visible persistence refers to the "extension of the visual stimulation beyond the termination of the stimulus itself" (Bowen, Pola, and Matin, 1974 *Vision Research* **14**(4) 295–303). The aim of this study was to investigate minimal persistence duration and variables that might affect it using stimuli with infinitesimal duration. We used random dot kinematograms (RDKs) where on the transition from one RDK to a second one all pixels in an annulus-shaped area changed luminance polarity, creating physically a single second order luminance transient. Phenomenologically, this transient signal typically produces the percept of an annulus with an abrupt onset and a gradual offset. We varied the radius and thickness of the annulus and measured its visible persistence by letting subjects match the onset of an auditory or visual reference stimulus to the onset and offset of the illusory annulus. The results showed that auditory reference stimuli yield longer persistence estimates than visual ones. Furthermore,

persistence increased with stimulus size. We discuss whether this increase is better explained by a simple function of stimulus energy or by a filling-in mechanism.

◆ **On the problem of shape formation: New effects related to Oppel-Kundt and Helmholtz's square illusions**
76

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According to the Oppel-Kundt illusion, an empty (unfilled) space looks wider than a space filled by some objects (Oppel, 1854–1855). This illusion is related to Helmholtz's square, where a square appears wider when it is filled with vertical lines and higher when filled with horizontal lines (Helmholtz, 1866). Recently, Pinna (2010, 2011) demonstrated the rectangle illusion, according to which, given a large square shape made up of small squares, the grouping of the small squares on the basis of the similarity principle influences the shape perception of both small and large squares. The direction imparted by grouping is the attribute that influences the shape by polarizing it in the same direction both globally and locally. The rectangle illusion is opposite to what expected on the basis of Oppel-Kundt and Helmholtz's square illusions. Aim of this work is to solve the antinomy between the two sets of illusions and to demonstrate a common explanation based on the interaction between different sources of directional organization. This was accomplished by introducing some new phenomena and through phenomenological experiments proving the role played by the directional shape organization in shape formation. [Supported by Finanziamento della Regione Autonoma della Sardegna, ai sensi della L.R. 7 agosto 2007, n. 7, Fondo d' Ateneo (ex 60%).]

◆ **Changing shape by changing accents in space and time: Visual and musical shape illusions**
77

B Pinna (Dept of Architecture, Design and Planning, Univ of Sassari at Alghero, Italy; e-mail: baingio@uniss.it)

Pinna and Sirigu (2011) demonstrated a new principle shape formation called the accentuation principle, stating that, all else being equal, the elements tend to group in the same oriented direction of the element discontinuity placed within a whole set of continuous/homogeneous components. The discontinuous element is like an accent, ie, a visual emphasis within a whole. It was shown that the accentuation principle can influence grouping and shape formation not only vision but also in music perception. Aim of this work is to study the role of simultaneous multiple sources of accentuation (synergistic and antagonistic), including the rhythm, in forming visual or musical shapes. Some new illusions, where the same stimulus pattern can be perceived like different possible and as alternative visual or musical shapes, are studied through phenomenological and psychophysical experiments. The results demonstrated that the accentuation principle strongly influences not only the shape but also the grouping and the figure-ground segregation in both visual and musical domains. Our outcomes weaken Ehrenfels's general law according to which we can recognize a melody as one and the same even though it has been transposed into a different key or has been played on a different instrument or at a different speed. [Supported by Finanziamento della Regione Autonoma della Sardegna, ai sensi della L.R. 7 agosto 2007, n. 7, Fondo d' Ateneo (ex 60%).]

◆ **The elaboration of "double overturn" method for the research of visual image formation**
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The new method for research of visual image formation was developed. The method allows separate three components of perception: sensory "fabric", meaning and personal sense (Leontev, 1975 *Activity, Consciousness, and Personality* Moscow, Politizdat). The participants looked at the doll's room through the invertoscope. This toy room was really overturned and all interior items were glued. So we named our method «double overturn». The participants were asked to describe the visual scene and to do actions in the space of toy room (to put the spoon into the cup). The experimenter could manipulate with things in the room too (pour out the sugar from the teapot to ceiling of overturned room). It gets the opportunity to oppose the sensory "fabric" and the meaning of perceived scene against objective reality whereas in famous experiments with the invertoscope the sensory "fabric" and the meaning were opposed. The results with 59 participants showed: (1) the observers didn't notice the scene was really overturned; (2) to encourage them to notice the overturn, the sensory "fabric" and meaning have to be collided; (3) for this purpose, both observer's and experimentator's actions were an equal success; (4) a number of illusions were observed in the both cases.

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◆ **The sensorimotor measurements of perceptual illusions**

79 V Karpinskaia¹, V Lyakhovetski² (¹Saint-Petersburg State University, Russian Federation; ²Pavlov Institute of Physiology RAS, Russian Federation; e-mail: karpinskaya78@mail.ru)

The role of interhemispheric asymmetry at the sensorimotor measurements of Muller-Lyer illusion was investigated. We used the illusion of perception as a phenomenon of consciousness to find out how the error's value depends on the left and right hemisphere contribution to the control in decision-making. We compared the precision of the left and right hand's movements on the touch screen during the measurement of the segments length. It was found that the left and right hand controlled by two hemispheres by different ways had made different errors during these measurements. The constant bias of the right hand's movements is larger than for the left one. The conclusion is that the hemisphere mostly involved in movement control determines the dominant system of representation (metric and categorical) and the control's type in decision-making (automatic or conscious).

◆ **The early time course of the Delboeuf illusion**

80 F Schmidt, T Schmidt, A Weber (University of Kaiserslautern, Germany; e-mail: andreas.weber@sowi.uni-kl.de)

In the Delboeuf illusion the perceived size of a circle is modulated by the size of a surrounding annulus. Because only little is known about the early time course of this effect, we studied the illusion within a response priming experiment. In each trial, we simultaneously presented a small and a large peripheral target circle on the left and right side of fixation. Participants responded to the position of the one or the other by pressing a left or right button. Shortly before the targets we presented small, large, or medium-sized central primes that were consequently consistent, inconsistent, or neutral with respect to the required response. In the critical condition, neutral primes were surrounded by annuli rendering them smaller or larger. Importantly, this manipulation produced response priming effects as would be expected if the illusion was effective also in fast visuomotor processing. However, the magnitude of these effects strongly depended on response speed, with larger priming effects in slower responses. We discuss our findings within the framework of a dichotomy between a temporally early, coarse and global visual processing style versus a late, fine and local one. Only the latter would be able to integrate illusory percepts.

◆ **The parallelogram: a perceptual enigma**

81 F Halper (Harvard University, USA; e-mail: fhalper@wjh.harvard.edu)

Veridical perception of planar nonrectangular parallelograms is difficult, with new paradoxes of organization recently observed (Tyler, 2011 *i-Perception* 2 137–141). A Sunoco gas station canopy of such shape in New Jersey, 40°50'18.28"N 74° 09'23.76"W (©Google (2010) Google Earth (v.6.0)) is a real-world example. Four subjects shown 10 surrounding views, all reported with strong confidence, the canopy as rectangular. Presenting single images, the canopy is accurately seen by only 7% of 116 subjects, making a choice from 4 alternative shapes, as viewed from above. Eighty percent of subjects pick a rectangle or square, with the remainder opting for quadrilaterals. Although the canopy is level with the ground, 20% of subjects report it to be tilted. This is less robust than the illusory tilt of attached Manhattan balconies of the same shape (Halper, 1997 *Perception* 26 1321–1322), where the vertical surface of the building provides relative information about right-angularity. Another group of subjects viewed photos of a Sunoco canopy whose shape is square. Although veridicality tripled, rectangles were chosen 58% of the time, with the total of right-angled shapes perceived being the same (81%) as the parallelogram. A conclusion is that gravity, in nature and architecture, pushes the visual system to organize four sided figures as right-angled.

◆ **From physical to perceptual stimulus representations: Exploiting the Ebbinghaus illusion in a response priming paradigm**

82 A Weber¹, L Noé¹, L Hoffmann¹, T Schmidt², F Schmidt² (¹TU Kaiserslautern, Germany; ²University of Kaiserslautern, Germany; e-mail: filipp.schmidt@sowi.uni-kl.de)

Stimulus representations change over time in visual processing from early stimulus-governed representations to later perceptual interpretations. The study of the time-course of visual illusions is an insightful approach to follow this continuum within visual perception. In the Ebbinghaus illusion the perceptual size of an object is increased/ decreased if it is surrounded by smaller/ bigger context elements. In a response priming paradigm, participants reacted to the position of the smaller/ bigger of two simultaneously presented target circles. Target stimuli were preceded by prime circles whose perceptual sizes were modulated by different versions of the Ebbinghaus illusion. By rendering the

primes smaller or bigger, the illusion led to response-consistent or inconsistent configurations of primes and targets. Regression analyses revealed a continuum between two qualitatively different result patterns: Slow participants/ trials showed priming effects in the direction of the illusory percept while fast participants/ trials showed opposing priming effects. Thus, within our measurement we were able to completely record the continuous transition from physical to perceptual stimulus representations. Inferences about the respective properties are discussed.

◆ **Perceived display speed helps account for the ‘jitter advantage’ in vection**

83 D Apthorp, S Palmisano (University of Wollongong, Australia; e-mail: dapthorp@uow.edu.au)

Illusions of self-motion in depth (‘vection’) are strongly enhanced when coherent viewpoint oscillation or jitter is added to the inducing optic flow displays (Palmisano et al, 2010 *Perception* **29** 57–67). The underlying cause of this “jitter advantage” is still unknown. Here we investigate the possibility that perceived speed plays a role, since other manipulations that increase perceived speed (adding stereo, using contracting rather than expanding flow) also increase vection in depth, and reducing perceived speed reduces vection. First, in a 2AFC procedure, we measured PSEs for smooth and vertically oscillating motion-in-depth displays; oscillating displays were uniformly perceived as faster. Then we used throttle and verbal measures to measure strength, duration and onset latency of vection in oscillating and smooth linear vection displays matched for real and perceived speed. The oscillation advantage was eliminated when displays were matched for perceived speed. Adding motion blur increased vection while leaving retinal speed constant. We tested whether observers were misattributing vertical motion to MID in a further 2AFC estimation of oscillation magnitude, but this was not the case. Testing with random viewpoint jitter, we found that jittering displays produced greater vection than speed-matched displays, suggesting there may be separate mechanisms driving jitter and oscillation effects.

◆ **Texture-region analysis at the basis of the illusory enlargement of a filled area**

84 E Giora¹, S Gori² (¹Dept of Psychology, University of Milano-Bicocca, Italy; ²Dept of General Psychology, University of Padua, Italy; e-mail: enrico.giora@unimib.it)

Similar to what happens in the Oppel-Kundt phenomenon, an area filled by clearly distinguishable subparts appears larger than an empty space of identical physical size. The perceptual overestimation depends on textural properties and results to increase with spatial frequency and decrease with the microelements’ number (Giora and Gori, 2010 *Vision Research* **50**(23), 2466–2475). Two alternative approaches account for texture processing: edge- and region-based models. In the present research we investigate whether the phenomenon of area enlargement is based either on an edge-based analysis, focused on the boundaries’ information, or on a holistic processing of all the texture-region. We tested the perceived size of figures filled by textural micropatterns either only at the boundaries or in the entire texture. Textured stimuli were compared to uniform figures, whose size observers had to adjust. Results showed that the perceived size increased proportionally with the amount of textured area and confirmed the crucial role of spatial frequency and microelements’ number. We concluded that perceiving the size of visual objects involves a holistic analysis of textures, sensitive to the statistical properties that are processed throughout the entire texture-region.

POSTERS: APPLIED VISION

◆ **Involving people in colouring their streets: From virtual images to a public art intervention**

85 G Caporusso¹, S Feduzi¹, L Oppo², M Putzu², M Murgia¹ (¹Università di Trieste, Italy; ²Noart-Paese Museo Cultural Association, Italy; e-mail: gcaporusso@units.it)

Environmental changes would benefit of the involvement of people living in that environment. This would make them to feel an active part of the changing process. The present work is part of a participatory planning project conducted in a small Sardinian town, San Sperate. The aim of the research was to provide engineers and architects with population’s judgments about a public art intervention aimed to colour the streets of their town. Pictures of the street with different asphalt colours were used as stimuli. Participants were 184 people resident in these streets, who were asked to rate virtual images representing 6 possible asphalt colours, on a likert scale from 0 to 10. The results evidenced that participants rated with higher scores those colours that fit well with the walls of the houses. Subjects’ preferences were communicated to the engineers and architects, who planned the intervention on the basis of population’s preferences. Concluding, we demonstrated that experts in visual perception, adopting a paradigm typical of the environmental psychology, can apply their knowledge in the social context.

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◆ **Estimating weight and height based on mental norms: A cross-cultural study from Germany and Japan**

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The ability to exploit features of the human face to predict health and fitness can serve as an evolutionary advantage. Facial symmetry, averageness, and skin colour are known to influence health and fitness. However, numerous studies have found that human judgments are biased by diverse prototypes, cultural norms, and social heuristics. Are we able to use variables like weight and height to validly estimate human health and fitness by the mere inspection of the face, or could we expect that weight judgments on the basis of faces are biased by culturally shaped body prototypes? We used a cross-cultural approach with Caucasian versus Asian observers rating Caucasian and Asian faces. Participants used a heuristic based on their own cultural norm of weight (and height), as estimations were superior for faces of their own ethnicity. Accordingly, participants used a very similar heuristic for estimating weights of women versus men for both ethnicities based on the norm difference between the sexes of their own ethnicity. Taking into account that body estimations were historically limited to one's own ethnicity, such a simple heuristic makes sense, but leads to systematic biases in a globalized world.

◆ **Towards an emotional footprint: Non-verbal analysis of emotionally processed visual stimuli via posturography**

87

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The emotional impact of visual content is of great interest in fundamental research such as empirical aesthetics as well as in applied topics like the evaluation of usability and design appreciation. Measuring emotions elicited by visual stimuli, however, is a major challenge due to cognitive penetration in usual verbal reports, low temporal resolution in EDA, and general problems in revealing the valence of psychophysiological measures retrieved by EEG and fMRI. To overcome all these drawbacks, we propose posturography, which we employed with low cost commercial hard- and software. The utilized setting shows high temporal resolution (100Hz) and is capable of reliably tracking a person's balance control. A pilot ($n=5$) showed high and distinct postural responses to visual emotional stimuli. In a further study ($n=21$) we presented 23 distinct high-quality images (selected in a pre-study, rated for emotional intensity and value) in randomized order, each preceded and followed by an isoluminant mask, while the subject was standing on the balance board. The data reveal significant postural responses to emotional content with distinct patterns for several so-called base-emotions. Future research aims to identify the specific "emotional footprints" for providing a reliable and valid instrument for measuring emotions elicited by visual stimuli.

◆ **Is there a common trait of aesthetic assessment or does it depend on the assessed content?**

88

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People judge artworks with a view to different aesthetic dimensions (Augustin, Carbon, and Wagemans, 2011 *Perception* 40). But to what extent do they assess different art objects in a homogenous way, according to a general aesthetic trait? A latent multiple-state-model (Steyer, Schmitt, and Eid, 1999 *European Journal of Personality* 13(5), 389–408) was used for different artworks, exploring possibilities to build a latent multiple-state-multiple-trait-model. Data of six different artworks were analyzed, which differed in their figural and abstract content (2 x landscape, 2 x persons, and 2 x abstract) and had been presented in random order to a mixed sample ($N=304$). To reduce complexity of the model we focused on three of five dimensions from an extended questionnaire (Augustin et al 2011): Comprehensibility, Emotiveness and Pleasingness, with two indicator variables per dimension. The latent multiple-state-model with six pictures produced an acceptable fit, confirming the assessment structure. The intercorrelations of the equal latent dimensions were high for figural but not for abstract paintings. In consequence, it was not possible to realize an acceptable model with generalized single-traits for each state dimension within this study. Possible implications for the assessment of aesthetic objects are discussed.

◆ **A computational model for saliency detection based on probability distributions**

- 89 D A Klein¹, G Martin Garcia¹, S Frintrop² (¹Dept of Computer Science III, University of Bonn, Germany; ²Dept of Computer Science III, University of Bonn, Germany; e-mail: frintrop@iai.uni-bonn.de)

The detection of salient items is a key property in human perception which is also of significant interest in technical fields such as computer vision. For example, the detection of salient items in web images facilitates tasks such as object segmentation and recognition (Liu et al, 2009 *Transactions on Pattern Analysis and Machine Intelligence* **33**(2), 353–367). Here, we present a new way to compute saliency efficiently by using new methods for the representation of features and the computation of center-surround differences. Image regions are represented by multivariate normal distributions and compared with the Wasserstein metric. This is a well-known method to compare probability distributions and is especially suited to compute saliency since it considers also the similarity of feature values. We evaluated the method on psychophysical patterns as well as on a benchmark of natural images containing salient objects (Achanta et al, 2009 *Proceedings of Computer Vision and Pattern Recognition* 1597–1604) and show that the new approach outperforms nine state-of-the-art saliency detectors in terms of precision and recall.

◆ **Fast and accurate multi-scale keypoints based on end-stopped cells**

- 90 K Terzic, J Rodrigues, J Du Buf (Vision Laboratory, LARSys, University of Algarve, Portugal; e-mail: dubuf@ualg.pt)

Increasingly more applications in computer vision employ interest points. Algorithms like SIFT and SURF are all based on partial derivatives of images smoothed with Gaussian filter kernels. These algorithms are fast and therefore very popular. Our own multi-scale keypoint algorithm (Rodrigues and du Buf, 2006 *BioSystems* **86** 75–90) is based on V1 end-stopped cells on top of complex cells with inhibition schemes to suppress responses along edges etc. Although producing good results, it is slow because of many filter orientations and scales. We therefore developed an improved algorithm which is much faster, because instead of using big filter kernels (Gabor filters as simple cells) at coarse scales, we apply a Gaussian pyramid and do all filtering in the frequency domain. Stability and localisation are improved by automatic scale selection and by smoothing response maps prior to detecting local maxima. Extensive benchmarking concerning repeatability, precision and computing speed showed that the improved algorithm compares to or even outperforms most algorithms from computer vision. Since the code will be made publicly available, our new keypoint algorithm can be applied in advanced biological vision models and in computer vision applications. [Projects: PEst-OE/EE/LA0009/2011, NeFP7-ICT-2009–6 PN: 270247.]

◆ **Relationship between imitating an expert's motion and improved motor skills**

- 91 Y Akasaka¹, M G Kamachi² (¹Graduate School of Engineering, Kogakuin University, Japan; ²Kogakuin University, Japan; e-mail: uya.aka@gmail.com)

Imitation is an important function in human development, and imitating an expert's motion is considered an efficient way for beginners to improve their motor skills. In this study, we investigated the relationship between an improvement in beginners' skill of throwing darts and how closely they imitated the expert's motion they observed. Fourteen male participants, all right-handed, participated in the experiment, and all were considered as beginners since they had little experience with darts. The experiment was conducted over two days. On the first day, all participants threw darts in their own way. On the second day, 7 of them were instructed to imitate an expert's motion by watching a video, and threw darts. The other 7 participants threw darts without observing the expert's motion. The motion similarity of the expert and both beginner groups was analyzed using an Angular Metrics for Shape Similarity (AMSS). The result showed that the score of the observing group was higher than that of the other group. In addition, the closer the beginner came to imitating the expert's motion, the more skilled the beginner became at throwing darts. We suggest that the degree of motion similarity has a bearing on the improvement of motor skills.

◆ **Glare and neural contrast: scene content controls the neural contrast response**

- 92 A Rizzi¹, J McCann² (¹DICO—UNIMI, Italy; ²McCann Imaging, USA; e-mail: alessandro.rizzi@unimi.it)

We collected magnitude estimates of scene lightness in white, black and average (half-white/half-black) surrounds (Rizzi et al, 2007 *JSID*) and then calculated their retinal luminance using Vos and van den Berg's glare spread function (1999 *CIE*). Each of the three sets of lightness magnitude estimates fit

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straight-line log luminance functions with different slopes. Gray appearances in a white surround fit the cube root of scene luminance, and the log of retinal luminance. Scattered light from intra-ocular glare accounts for the change in shape of the psychometric function. In a white surround, a retinal luminance range of 30:1 generates the entire appearance range from white to black. In a black surround, that white/black appearance range requires 100,000:1 retinal range, while the average surround requires a 100:1 retinal range. Scene content, namely, the amount of white area, controls the appearance of grays. The three scene-dependent psychometric functions of retinal luminance shows that the neural contrast processing of retinal luminance responds to the spatial content of the scene. The greater the retinal glare, the greater the neural contrast processing producing higher apparent contrast.

◆ **Motion processing deficits in migraine, contrast sensitivity and what is relevant noise for a visual motion task**

93

A Shepherd¹, H Beaumont², T Hine² (¹Birkbeck, University of London, UK; ²Griffith University, Australia; e-mail: a.shepherd@bbk.ac.uk)

Background: There are conflicting reports concerning the ability of people with migraine to detect and discriminate visual motion. Enhanced coherent motion detection, yet impaired global motion discrimination, has been reported and the latter attributed to functional differences in extrastriate cortex in migraine. Previous studies have used different types of motion displays and none has adequately assessed other parameters that could affect performance. Methods: Motion-direction detection, discrimination and relative motion thresholds with random dot displays were compared from participants with migraine with and without aura and from control participants. Potentially relevant visual covariates were included (contrast sensitivity: CS; acuity; stereopsis; visual discomfort; visual stress; visual triggers; dyslexia). Results: For each motion task, both migraine groups were less accurate than the control group. Both migraine groups also had impaired CS, greater visual discomfort, visual stress and visual triggers. Only CS correlated with performance on each motion task, it also mediated performance. Dynamic visual noise (twinkling dots at 20 HZ) added to the relative motion task improved performance for the migraine group only, compared to static visual noise. Conclusions: Impaired performance on certain motion tasks can be attributed to impaired CS early in the visual system. There were additional differences between the groups for global and relative motion thresholds embedded in noise, suggesting changes in extrastriate cortex. Tasks that can distinguish the effects of noise on performance at different levels of the visual system are recommended in future basic and clinical research.

◆ **High-precision psychophysics on the iPad**

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M Dorr¹, L Lesmes¹, L To¹, Z Lu², P Bex¹ (¹Schepens Eye Research Institute, USA; ²Ohio State University, USA; e-mail: michael.dorr@schepens.harvard.edu)

Precise assessment of visual function, eg contrast sensitivity, typically requires large and expensive laboratory setups and long testing times. Digital display devices such as TFTs often suffer from limited luminance and spatio-temporal resolution, and CRTs with video attenuators are therefore still being used for precise stimulus control. In order to overcome these limitations, we implemented the quick CSF method (Lesmes et al, 2010 *Journal of Vision* 10(3)17, 1–21) on an Apple iPad2. We developed a novel and efficient algorithm to extend the display's contrast resolution from a minimum luminance increment of 1.2% at mean luminance to <0.2%. The integrated camera was utilized to monitor viewing distance, eliminating the need for a chin rest. Using repeated measurements from four observers with normal/best-corrected and optically blurred (+4D) vision, we showed that reliable CSF estimates with peak sensitivities of 0.6–0.8% can be obtained in 5–7 min and that these estimates are indistinguishable from those obtained with a CRT and video attenuator setup. With our system, it becomes feasible to rapidly and precisely measure contrast sensitivity inside and outside the laboratory, for example to collect population data, improve eye care delivery in medically underserved areas, and closely monitor the progression of visual neuropathologies.

◆ **A simple clinical test for assessing performance in areas V1 and MT**

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L Bowns (University of Nottingham, UK; e-mail: l.bowns@nottingham.ac.uk)

The problem: to produce a simple clinical test that measures normal performance in areas V1 and MT. Method: The test uses optimised moving plaid stimuli that requires an observer to encode the orientation and motion of each component (V1), and then recombine the components to form pattern motion (MT). The test controls for all known variables that effect motion direction and importantly cannot be done using second order motion. The test uses a method of constant stimuli and a forced choice task. Observers decide if the moving plaid is moving clockwise or anticlockwise relative to a

fixed line. The test results reported here cover a four octave range of spatial frequencies at different directions at 45 deg. intervals around a circle. Results: the observers in experiment 1 report that the task is simple and perform close to 100% correct. Experiment 2 showed that the results remain similar under informal and non-calibrated viewing conditions. Conclusions: the test would provide a simple screening test invaluable to many researchers and clinicians where cortical visual problems have been implicated, eg dyslexia, Alzheimer's disease, dementia, autism; or for screening purposes where visual information plays a very important role, eg drivers, pilots, or air traffic controllers.

◆ **Eye-movement planning during flight maneuvers**

96 L Chuang, F Nieuwenhuizen, H H Buelthoff (Max Planck Institute for Biological Cybernetics, Germany; e-mail: hhb@tuebingen.mpg.de)

How are eye-movements planned to access relevant visual information during flight control? From the cockpit perspective, there are two classes of visual information that are relevant for flight control. First, the changing visuals of the external world provide direct perceptual feedback on how the pilot's command of the control stick is affecting the aircraft's current position, orientation and velocity. Second, flight instruments provide abstracted and specific values—on factors such as the aircraft's compass bearing and vertical speed—that have to be continuously monitored, in order for the global objective of certain maneuvers (eg, turns) to be achieved. Trained pilots have to coordinate their eye-movements across this structured visual workspace (ie, outside view and instruments) to access timely and task-relevant information. The current work focuses on providing descriptions of these planned eye-movements. Eye-movements were recorded of pilots in a high-fidelity flight simulator (100° field-of-view) whilst they performed specific flight maneuvers. Fixation durations and transitions between the individual instruments and aspects of the external environment are represented as network graphs. This allowed us to formally describe the sources of information that were relied on across the different tasks and to compare actual performance to expert predictions.

◆ **Blavigator: a navigation aid for blind persons**

97 J Jose, M Moreno, J Pinilla-Dutoit, J Rodrigues, J Du Buf (Vision Laboratory, LARSyS, University of the Algarve, Portugal; e-mail: dubuf@ualg.pt)

Blavigator (blind navigator) is a vision aid for blind and visually impaired persons. It supports local navigation by detecting walkable paths in the immediate vicinity of the user. It guides the user for centering on the path. It also detects obstacles, both static and moving, in front of the user and just beyond the reach of the white cane, such that the user can be alerted. The user can choose between modulated sounds and synthesised speech for path centering and obstacle alerts. Local navigation works both indoor (corridors) and outdoor (sidewalks etc). Global navigation, for wayfinding in neighbourhoods and in buildings, is also possible, provided that a detailed geographic information system is available. Different technologies are used for localising the user: outdoor GPS reception, indoor triangulation of WiFi access points, and visual recognition of landmarks. Already working in realtime on a netbook computer with a simple webcam, the system is cheap, simple to install and maintain, and reliable with a user-friendly interface. The system is being tested in collaboration with ACAPO, the Portuguese association of blind and amblyopes. The ultimate goal is to use the system on a mobile phone with a built-in camera. [Projects: PEst-OE/EEI/LA0009/2011, NeFP7-ICT-2009-6 PN: 270247, RIPD/ADA/109690/2009; PhD grant SFRH/BD/82310/2011.]

◆ **CORF: A computational model of a simple cell with application to contour detection**

98 G Azzopardi, N Petkov (University of Groningen, Netherlands; e-mail: g.azzopardi@rug.nl)

We introduce a computational model of a simple cell, which combines the responses of model LGN cells with center-surround receptive fields (RF). We call it Combination of RFs (CORF) model. We use simulated reverse correlation to demonstrate that the RF map of the CORF model can be divided into elongated inhibitory and excitatory regions, typical of simple cells. Besides orientation selectivity, the CORF model exhibits contrast invariant orientation tuning, cross orientation suppression and response saturation, which are observed in simple cells. These three properties are, however, not possessed by the Gabor function (GF) model, which has gained particular popularity as a computational model of a simple cell. We use two public data sets of images of natural scenes with associated ground truth to compare the CORF and the GF models in a contour detection task, which is assumed to be the primary biological role of simple cells. In this task, the CORF model outperforms the GF model (RuG dataset: $t_{39} = 4.39$, $p < 10^{-4}$, Berkeley dataset: $t(299) = 3.88$, $p < 10^{-4}$). The proposed CORF model is more realistic than the GF model as it shares more properties with simple cells and it is more effective in contour detection.

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◆ **Cortical masking and action learning**

99 M Thirkettle, P Redgrave, K Gurney, T Walton, A Shah, T Stafford (University of Sheffield, UK; e-mail: m.thirkettle@sheffield.ac.uk)

Understanding the relationship between our actions and sensory events in the environment is a fundamental skill. Dopaminergic (DA) neurons in the basal ganglia are thought to be the neural substrate of the action-outcome learning mechanism. Responsible for detecting relationships between motor output and sensory input, allowing behavioural contingencies to be detected and new actions to be discovered. We have previously shown that visual input which cannot access the DA neurons directly via subcortical pathways and must instead first submit to early cortical processing are less effective for such action learning (Thirkettle, et al, 2011 *Perception* 40 ECVP Supplement, 33). It remains to be seen, however, if subcortical visual processing alone is sufficient to support action-outcome learning. Therefore we tested this with a motor learning task using reinforcing signals masked from cortical processing using constant-flash-suppression. Results show that masked reinforcing signals, which are unavailable to conscious access, are capable of supporting action-outcome pairing, but are less effective than unmasked stimuli. These results confirm our previous finding that subcortical visual pathways provide the bulk of the sensory input for action-outcome learning mechanisms, however they also suggest that the results of cortical processing contribute strongly to this system.

◆ **The spot that decides on the Gestalt: Gestalt psychology in the context of blindspot perception**

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Gestalt psychology provides a prominent fundament for understanding higher-level perception. Several rules, the so called Gestalt principles that describe how multiple visual features are perceptually integrated to a whole, enable mainly post hoc explanations clarifying interpretations of specific configurations as "Gestalts". The good Gestalt principle refers to the simplest interpretation building the Gestalt, but as simplicity is not perfectly defined the principle's predictive quality for ambiguous configurations is low. To specify corresponding processes, we presented 63 ambiguous configurations to our participants projecting the visual information essential for solving the ambiguity monocularly on the retina's blindspot. The employed configurations comprised three sets built up of images requiring filling-in mechanisms based on geometric (GP), experience-driven (EP) and culture-driven (CP) principles, respectively. Participants described how they perceived the image, de facto how they filled-in the non-existing visual information. GP was mainly used as validation condition to check the individual's typical capability of filling-in, CP as test for culture-driven and EP for experience-driven filling-in mechanisms, respectively. Participants showed clear general capabilities of filling-in (GP = 54.8%) with high test-retest reliabilities ($R_s = 0.87$). In CP and EP filling-in often yielded specific solutions for highly familiar images indicating factors of personal and cultural experience for solving ambiguity

◆ **An investigation into size-speed illusions in railway level crossing collisions**

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The prevalence of collisions between motor vehicles and trains at railway level crossing junctions has been a high-profile issue for many years in New Zealand and other countries. Errors made in judging a train's speed could possibly be attributed to motorists being unknowingly subjected to a size-speed illusion. Leibowitz (1985 *American Scientists* 95 558–562) maintained that a large object seems to be moving slower than a small object travelling at the same speed. Support has been provided for Leibowitz's theory from studies using simple shapes on a screen. However the reasons behind the size-speed illusion remain unknown and there is no experimental evidence that it applies in the approaching train situation. To investigate these issues, we tested observers' relative speed estimation performance for a train and a car approaching at a range of speeds and distances, in a simulated environment. A psychophysical method (2AFC) was used to establish the PSE for the two different-sized vehicles. The data show that participants significantly underestimate the speed of the train, compared to the car. A size-speed illusion seems to be operating in the case of the approaching train in our simulation and may also be a factor in some railway level crossing collisions.

◆ **Perception of synthetically generated interactive human emotional body expressions**

102 N Taubert, A Christensen, D Endres, M A Giese (University Clinic Tuebingen; Dept. for Cognitive Neurology, Germany; e-mail: martin.giese@uni-tuebingen.de)

The generation of reactive highly realistic human movements in computer graphics is a difficult problem. We investigate the perception of naturalism and emotional style from computer-generated interactions between human avatars, generated with a novel algorithm based on a hierarchical Gaussian process latent variable model (Taubert et al, 2011, KI-2011, 330–334), whose latent space includes dimensions for emotional style variation (neutral, happy, angry, fearful, sad). The model produces in real-time reactive human movement, such as handshakes, allowing for the separate control of emotional style (eg 'fearful' vs 'angry'), the type of motion and individually specific motion style. In addition, the model is capable of morphing between motion styles in a framework that generates reactive motion online. In order to validate our approach, we conducted a 'Turing test': a psychophysical study where human observers rate generated and natural emotional handshakes. We find that the distinction between natural and synthesized movements is difficult for human observers, supporting the adequacy of our method for the synthesis of stylized interactive human movements for applications in computer graphics and robotics. [Acknowledgments: EC-FP7-ICT-projects TANGO-249858, and AMARSi-248311, DFG project GI 305/4–1, and the Hermann Lilly Schilling Stiftung.]

◆ **Matching unfamiliar faces under ecological conditions: Factors of stimulus similarity and feature exchange**

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Face matching is considered a highly sophisticated process. However, unfamiliar face matching seems to be substantially based on iconic information and thus susceptible to pictorial changes (Carbon, 2008 *Perception* 37 801–806). Amongst others, effects of inversion and negativation, important variables for basic research have mainly been investigated. Meanwhile variables most relevant for applied research have not been addressed as frequently. We investigated the accuracy of unfamiliar face matching in the applied context of passport controls under controlled conditions. Participants were asked to identify depicted persons by the photos of their passports. Three kinds of features were manipulated systematically: Paraphernalia, internal features, and external features. Averaged across all conditions, participants showed an accuracy of 82.6%, which does not meet expectations regarding the reliability of passport controls. Effects of changed features on accuracy, sensitivity, and reaction times were measured. Results showed no impairing effect of changing internal features, a small but significant effect of changing paraphernalia, and a large effect of changing external features. The data pattern provides relevant information for understanding specific processes of unfamiliar faces as well as for revealing typical problems in applied contexts.

◆ **Spotting expertise in the eyes: billiards knowledge revealed by gaze shifts and detected through machine learning**

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In sports, as in other activities and knowledge domains, expertise is highly valuable. We assessed whether expertise in billiards could be deduced from the pattern of eye movements when experts, compared to novices, are simply observing a filmed billiard match with no specific task, and ad-hoc occluded billiard shots with a trajectory prediction task. Experts performed better than novices, both in terms of accuracy and response time. In addition experts did not need to mentally extrapolate the hidden part of the ball trajectory, a strategy used by novices, but fixated selectively the diagnostic points of the ball trajectory, in accordance with the metrical system used by billiard professionals to calculate the shot coordinates. Since eye movements of experts contain the signature of billiard expertise, we applied machine learning to classify expertise from the oculomotor behavior. By using saccade amplitude and direction as features, a Relevance Vector Machine classified correctly which group—novice or expert—the observers belonged to, with an accuracy of 83% and 77% respectively for the match and the shots. Our data suggest that the signature of expertise in billiards is hidden in the ocular scanpath, and that it can be accurately detected at the individual level.

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◆ **How elite batters coordinate the movement of their eyes and head to anticipate interception**

105 D Mann¹, W Spratford², B Abernethy³ (¹Vrije University Amsterdam, Netherlands; ²Australian Institute of Sport, Australia; ³University of Queensland, Australia; e-mail: d.mann@vu.nl)

The performance of elite athletes in fast ball-sports approaches the limits of visual-motor behaviour, yet very few studies have sought to uncover how these athletes use visual gaze to guide and control motor action. Visual gaze strategies change commensurate with the level of interceptive skill (Land and McLeod, 2000 *Nature Neuroscience* 3(12), 1340–1345), though the current understanding of motor behaviour is predicated on the strategies of lesser-skilled performers. In this study we recorded the eye and head movements of two of the world's best cricket batters and show that they use very specific gaze strategies which separate them from lesser-skilled batters, and from all batters examined previously. In particular, the elite batters use central vision to watch the bat hit the ball, a task beyond the capabilities of lesser-skilled batters. They do so (i) by producing large predictive saccades to anticipate the locations of ball-bounce, and bat-ball contact, and (ii) by precisely coupling the movement of their head to the flight-path of the ball, ensuring that the ball remains in a consistent egocentric direction relative to their head. Eye and head movements are a hallmark of expertise in batting; the findings are used to inform coaching practice in fast ball-sports.

◆ **Reversal rate of ambiguous figure after glare conditioning stimulus**

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The reversibility of an ambiguous figure seems to be determined by both bottom-up, stimulus-related manipulation, and top-down, attentional/cognitive, visual processing. Glare inducing stimuli modify the retinal input while causing fluctuation of attention at the same time, and therefore can affect the frequency of reversal. In order to study this possibility we measured the reversal rate of a Necker cube while intermittently presenting glare-inducing stimuli—bright homogenous field or series of flashes. The experiments were performed under mesopic viewing conditions with the Necker cube outlined in a positive contrast on a dark background. The experimental procedure was controlled by SuperLab Stimulus Presentation System (STP100W) connected to stimulator module STM 100C and a stroboscope TSD122A (Biopac, Inc.). The results obtained, while confirming the high interpersonal variability and the presence of fast and slow observers, showed that glare increases the reversal rate of the perceived orientation. Most of this outcome may be ascribed to nonspecific arousal changes. Considering the responses of myopic and emmetropic subjects revealed a trend for more pronounced change in the rate of reversal in emmetropes as compared to myopes. This difference may be a result of the higher sensitivity to glare in the myopic subjects under mesopic conditions.

◆ **Understanding bird egg patterning: assessing visual camouflage using visual difference and edge-detection models**

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Bird eggs can show a high degree of patterning, which is thought to enhance crypsis and thus avoid predation. Most studies to date have used manipulations of egg patterning to assess predation as a proxy for camouflage. Here we present the results of a study where Japanese quail were given a choice of four laying substrates (white, yellow, red or black sand). Laying locations were recorded for a period of 5 days. Egg detectability was quantified by measuring the amount of the egg to substrate boundary identified by the Canny edge detection algorithm. We further assessed laying choices by the estimating visual difference between the egg and each of the available substrates (To et al, 2010). The chosen laying position minimised the amount of edge contour found by the edge-detector. Somewhat counter-intuitively, we found that the chosen substrate also tended to be the least visually similar to the egg. We also detected a significant negative correlation between the chosen substrate albedo and the degree of maculation (darker speckling) of eggs. These results suggest that egg camouflage may operate via disruptive colouration and that females may use the degree of maculation as a cue to optimising individual laying positions.

◆ **Action videogame playing can improve visual-motor control without affecting vision**

108 L Li, R Chen, J Chen (The University of Hong Kong, Hong Kong; e-mail: lili@hku.hk)

We examined how action videogame playing affects visual-motor control using a manual control task in which participants used a joystick to keep a blob centered on a large display as its horizontal position was randomly perturbed. Six naive Non-Videogame Players were trained with an action videogame (Mario Kart Wii, Nintendo), and six were trained with a strategy videogame (Roller Coaster Tycoon

III, Atari) for 1–2 hours a day for 10 hours in total. Their performance on the manual control task was measured before the training, after 5-hour training, and after 10-hour training, and their contrast sensitivity function (CSF) was measured before and after training. For the group trained with the action videogame, the RMS error of their performance on the manual control task decreased by 14% (SD: 8%) after 5-hour training and by 20% (SD: 6%) after 10-hour training, and their overall control response (gain) increased by 24% (SD: 11%) after 5-hour training and by 32% (SD: 15%) after 10-hour training. The improvement sustained when they were retested on the manual control task between 2–4 months later. In contrast, no change of RMS or gain was observed for the group trained with the strategy videogame. For both groups, no change in CSF was found. We conclude that action videogame playing can improve visual-motor control without affecting vision.

◆ **Aligning fundus images via the automatic extraction of retinal surface vessels**

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Extraction of retinal surface vessels allows for fast registration of human fundus images. Two unsupervised, automatic blood vessel extraction algorithms were implemented. The first approach enhanced the surface vessels by applying Gabor filters (Oloumi et al, 2007 *Conference Proceedings of IEEE Engineering in Medicine and Biology Society* 6451–6454). The second approach combines multiple preprocessing steps to reduce the influence of noise within the images (such as the central light reflex) (Marín et al, 2011 *IEEE Trans Medical Imaging* 30 146–158). Both approaches resulted in similar accuracy (~94%) when applied to the DRIVE database of fundus images (Staal et al, 2004 *IEEE Trans Medical Imaging* 23 501–509). Spectroscopic fundus images were then aligned using the outputs of each approach. In particular, the automatically generated vessel masks for each fundus image were shifted both vertically and horizontally relative to a reference vessel mask. For each possible shift, the absolute difference between the two masks was computed. The translation that generates the minimal difference between the two masks was used to align the raw images. Thus, translations, resulting from minor eye tremors and movements, were corrected. Spectroscopic fundus images can then be used to calculate the relative oxygenation of different retinal compartments.

POSTERS: EMOTIONS

◆ **Inverting natural facial expressions puzzles you**

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The face inversion effect has often been demonstrated in face identification tasks. Less is known about whether processes underlying face expression recognition are also sensitive to face inversion. Face expression recognition is usually investigated using pictures of six emotional expressions. In everyday life, humans are however exposed to a much larger set of facial expressions, which are dynamic. Here, we examine the effect of face inversion on expression recognition for a variety of facial expressions displayed statically and dynamically. We measured participants' recognition accuracy for 12 expressions using a 13 alternative-forced-choice task. We varied the dynamics (videos versus pictures) and the orientation (upright versus inverted) of the presentation of the expressions in a completely crossed design. Accuracy was significantly higher when expressions were presented as videos (62%) than as pictures (47%). Similarly, recognition accuracy was significantly higher for upright (84%) compared to inverted (64%) expressions. Moreover, the effect of orientation changed significantly with expression type. No other effects were significant. This is the first study to report that face inversion affects the recognition of natural facial expressions. Because face inversion effects are interpreted as a sign of configural processing, our results suggest configural processing for a majority of facial expressions.

◆ **Factors affecting orienting behaviour to emotional expressions: stimulus duration, spatial frequency and response mode**

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It is often assumed that threat related stimuli are preferentially detected and oriented to, as they are consistently of significant value to an observer. The behavioural evidence however are mixed, as anxious individuals show preferential processing of fear stimuli, however, the cueing effects in healthy observers do not show a threat advantage. In a series of investigations, we have measured saccadic and manual

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responses as an indicator of orienting behaviour to emotional expressions in face stimuli. We have shown that in normal observers, a fear advantage can be seen but only for briefly presented stimuli (20ms) when saccadic responses are measured, whereas manual response measures need longer stimulus durations (100ms). We will also report on the role of spatial frequencies on fast saccadic orienting behaviour. Single face stimuli (fear, happy, neutral) filtered to contain mainly low, high or broad spatial frequencies were presented briefly (20ms). Preferential processing of emotional stimuli was shown in all but the high spatial frequency condition, with faster orienting to fear than happy stimuli only at low spatial frequencies. There were no differences in saccadic responses between any emotions at HSF. A range of control experiments show that the findings cannot be attributed to low level stimulus artefacts.

◆ **Components of subjective experience of visual objects and scenes**

112 S Markovic (University of Belgrade, Serbia; e-mail: smarkovi@f.bg.ac.rs)

The purpose of this study was to specify the underlying structure of subjective experience of visual objects and scenes. Subjective experience includes features imposed upon the scene by the perceiver (eg pleasure, interestingness, etc). In preliminary study 1 a set of twenty photographs of various visual stimuli (humans, objects, natural scenes etc) was selected. In preliminary study 2 a set of forty-nine representative descriptors of subjective experience of the visual world was selected (the descriptors were then transformed in the form of bipolar scales, eg pleasant-unpleasant). In the main study sixteen participants judged twenty stimuli on forty-nine scales. Using the 'stringing-out' method a unique matrix of judgments was created. In the factor analysis (principal component method plus Promax rotation) three main factors were obtained: Attraction (most saturated scales: attractive, interesting, good, beautiful, etc), Regularity (regular, organized, harmonious, connected, etc) and Relaxation (relaxed, calming, non-offensive, tender, etc). Regularity referred to the perceptual aspect of subjective experience including the impression of figural goodness, compositional harmony and the like. The other two factors referred to two different affective domains: Attraction represents appetitive tendencies in behavior (actions towards attractive and interesting stimuli), whereas Relaxation represents hedonic effects of reduction of tension.

◆ **Subjective feeling of fluency and affective response**

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According to the fluency hypothesis, the objective fluency of a perceptual process is accompanied by a subjective experience. This experience or subjective feeling can be a strong source for later judgments, particularly liking judgments (Forster et al, submitted). According to psychobiological approaches, the affective response (arousal or valence) towards an object should also influence object preference. Interestingly, it has not yet been thoroughly studied whether fluency may also play at least a mediating role in our affective responses. Therefore, we conducted a series of experiments addressing measurement of the feeling of fluency and its impact on liking, as well as on arousal and valence. Our results indicate that the feeling of fluency can be explicitly reported and is related to objective fluency. Analyzing the influence of objective fluency manipulated through differences in presentation duration, we found that liking and arousal ratings-but not valence ratings-were influenced by manipulations of fluency. However, a higher subjective feeling of fluency led to higher ratings in all three dimensions (liking, arousal, and valence). This indicates that the feeling of fluency may be an important source for explaining the interplay of affective responses to and evaluations of an object.

◆ **Registering eye movements in collaborative tasks: methodological problems and solutions**

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Our studies are rooted in long-standing tradition of studying cognitive processes in communication that stems from the approach developed by Lomov in the 1970s and numerous studies of oculomotor activity launched by Yarbus (1967, *Eye Movements and Vision*, New York, Plenum Press) and followers. Modern eye-tracking technologies make possible combination of these approaches and conduct of new types of studies in joint activities and communication. However, organization of such experimental setups requires a number of methodological problems to be solved. Stationary eye-trackers can be used in dyadic experiment with minor adaptation, namely special software for synchronization of dual stimuli presentation, eye movement and speech registration. This being realized, we conducted two

experiments in joint perception of (1) faces of different racial type and (2) basic facial expressions. In both series either similar or slightly different (modified with morphing procedure) stimuli were presented to the participants instructed to determine whether they observe same or different pictures. The data thus collected suggest specific coordination of cognitive processes (visual search, "joint attention"). Several episodes of fixational patterns overlap were observed. We propose that the amount of eye movements synchronization registered in collaborative tasks can predict the efficiency of collaboration and participants' joint performance. [Supported by GK 16.740.11.0549.]

◆ **Playing a violent videogame with a gun controller has an effect on facial expression recognition but no selective effect on prosocial behaviour**

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Playing a violent videogame has both a (i) perceptual and (ii) social effect, reducing respectively the happy face advantage (ie happy faces are recognized faster than sad faces) (Leppanen and Hietanen, 2003 *Emotion* 3 315–326) and prosocial behaviour (Sheese and Graziano, 2005 *Psychological Science* 16 354–357). Here we investigated whether playing with a more realistic and interactive device enhances these negative effects. We asked participants ($n=45$) to play either a neutral (sport, Group 1) or a violent videogame with a Nintendo Wii. The violent videogame could be played either with a standard controller (Group 2) or with a Gun shaped controller (Group 3). Before and after each playing session participants underwent prosocial behaviour self-rating projective measures. Following the videogame task, they were asked to recognize emotional facial expressions—unambiguous vs ambiguous—from the Ekman and Friesen database. Results showed no effect on recognition times, but a significant interaction between accuracy and ambiguity in recognizing positive vs negative emotions across Groups. Prosocial behaviour ratings significantly decrease in all groups, suggesting that the negative effects of playing could be more related to frustration than violence. The results are discussed in relation to the interplay between action, perception and social cognition.

◆ **Changes in the fractal dimensions of facial expression perception between normal and noise-added faces**

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Many studies have reported that the structure of facial expression perception can be represented in terms of two dimensions: valence and arousal. Some studies have shown that this structure possesses a fractal property; the fractal dimensions of such structures differ significantly for short and long stimulus durations (Takehara et al, 2006 *Perception* 35 ECVF Supplement, 208) and photographic positive and negatives (Takehara et al, 2011 *Perception* 40 ECVF Supplement, 74). In this study, we examined the changes in the fractal dimensions of the structure of facial expression perception by using normal and noise-added faces as stimuli. A statistical analysis revealed that the fractal dimension derived from noise-added faces (1.43 dimension) was higher than normal faces (1.32 dimension); $t_{23}=3.53$, $p<0.01$. Consistent with previous studies, a higher fractal dimension was considered to be related to difficulty in facial expression perception. On the other hand, correct response rate for noise-added faces was reduced since the noise on the faces disrupted high spatial frequencies (McKone et al, 2001 *Journal of Experimental Psychology: Human Perception and Performance* 27(3), 573–599). Therefore, our results might suggest that a higher fractal dimension in noise-added faces are related to disruption of high spatial frequencies.

◆ **Explicit and implicit contamination sensitivity in children with autistic spectrum disorders: an eye tracking study**

117 R Fadda, M Siegal, P G Overton (Dept of Psychology, University of Sheffield, UK; e-mail: pcp09rf@sheffield.ac.uk)

Contamination sensitivity, which typically emerges at around 4yrs of age thanks to a combination of cognitive abilities and social learning processes, seems to be particularly impaired in children with Autistic Spectrum Disorders (ASDs; Kaliva, Pelizzoni et al, 2009 *Research in Autism Spectrum Disorders* 4(1):43–50). However, since contamination sensitivity has been investigated only through behavioral studies, to what extent children with ASDs who lack explicit contamination sensitivity in behavioral tasks are not implicitly sensitive to disgust elicitors needs to be specifically investigated. In this study we evaluated implicit contamination sensitivity in 15 children with ASDs who lack explicit contamination sensitivity (ASDnocs), compared with 15 children with ASDs who showed

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explicit contamination sensitivity (ASDcs) and 30 TD controls, through an eye-tracking intermodal preferential looking paradigm. The results showed that TD and ASDcs had a looking preference for an uncontaminated drink in sharp contrast to children with ASD who did not possess contamination sensitivity. Therefore children with ASDs who lack explicit contamination sensitivity also lack an implicit sensitivity to disgust elicitors, highlighting the importance of pairing behavioral tasks with eye-tracking measures to fully assess clinical populations.

◆ **Congenital Prosopagnosia: The role of changeable and invariant aspects in famous face identification**
118

A Albonico, M Malaspina, R Daini (Psychology Dept, Università degli studi di Milano-Bicocca, Italy; e-mail: nea.albonico@gmail.com)

The role of non-emotional changeable aspects in face recognition has been less considered than the dissociation between facial invariant features and emotional expressions. Indeed, the idiosyncratic movements of a specific face can help the recognition of the face itself (O' Toole et al, 2002 *Trends in Cognitive Sciences* 6(6) 261–266). We aimed at understanding if congenital prosopagnosics, ie subjects with impairment in face recognition from birth, can use that information to improve their familiar faces identification. We selected two groups of 14 subjects, one with poor performance in face episodic recognition tasks (experimental) and the other with good performance in the same tasks (control). Videos of 16 famous persons were presented in three different conditions: motionless, with non-emotional expressions, with emotional expressions. The results showed an effect of the group, indicating that the group selected as lower performers in face episodic recognition tasks also performed poorly with a famous people identification task. Moreover, the experimental group increased its performance from motionless condition to conditions with facial movements, whereas the control group did not show any difference among conditions. The results suggest an important role of changeable aspects, other than emotional expressions, in face recognition of congenital prosopagnosics.

◆ **Discrimination of real, but not morphed, facial expressions correlates with emotional labeling**
119

O A Kurakova (Center for Experimental Psychology MCUPE; Moscow Institute for Psychoanalysis, Russian Federation; e-mail: olga.kurakova@gmail.com)

The ability to discriminate between similar emotional facial expressions may depend on interaction of verbal labeling them as belonging to different emotional categories, and noncategorical system for low-level discrimination (Roberson et al, 2010 *Emotion Review* 2 255–260). We applied the classical paradigm of inspecting categorical perception to novel emotional faces dataset to reveal differences in discriminating natural and artificial transitional FEs. In our study, two sets of stimuli were used: photographic images of 6 transitions between posed basic emotions and 6 morphed transitions between same emotional prototypes. Using Differential Emotions Scale, the prototypes were evaluated by subjects as having different emotional profiles. Discrimination involved AB-X task; the identification task was 7-way multiple choice between basic emotions labels. Theoretical discrimination performance between consequent images in transitions was predicted as sum of absolute differences in labeling rates for all emotions. The results showed positive correlation of theoretical and empirical (AB-X) discrimination performance for photographic transitions, but not for morphed ones. Instead, empirical discrimination of morphed images correlated positively with physical between-stimuli distances. We propose that discrimination of sequential photographs of posed transitions between basic FE relies mostly on emotional labeling, whereas picking out differences between artificial morphs requires predominantly low-level percepts comparison. [Supported by RFH grant no. 12–36–01257a2.]

◆ **Your face looks funny: The role of emotion on perceived attractiveness of face images**
120

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In the domain of facial attractiveness, the role of factors such as averageness and symmetry have been investigated primarily using static face images with a neutral expression. However, facial attractiveness can be modulated by factors such as facial expression or social information about the person. For example, face images associated with 'humorous' descriptions are rated as more desirable than face images described as 'non-humorous' (Bresler and Balshine, 2006 *Evolution and Human Behaviour* 27 29–39). In experiment 1 we manipulated the proportions of a particular emotional facial expression across a number of exposures to unfamiliar face images. We found that attractiveness ratings increased as the proportional number of 'happy', but not fearful, expressions increased relative to the number of neutral expressions. In experiment 2 we investigated if attractiveness ratings were influenced by cross-sensory

emotional information provided during exposure to the face images. Ratings were compared across face images associated with auditory emotional (eg 'humorous' description or laughter) or neutral (eg 'neutral' description or coughing) information. The emotional content, particularly positive emotion, effected preferences for some faces over others. Our findings suggest important cross-sensory influences on the perceived attractiveness of a static facial images.

◆ **Effects of direction, intensity range, and velocity on perception of the dynamic facial expressions**

121 H Inoue¹, M Ichikawa² (¹Graduate School of Humanities and Social Sciences, Chiba University, Japan; ²Faculty of Letters, Chiba University, Japan; e-mail: h.inoue@chiba-u.jp)

When observing a sequence of dynamic facial expressions, perceived emotional intensity for the last face in the sequence tends to shift toward the direction of expression change. For example, the observers would perceive the neutral face as happy (angry) face if it is presented as the last face in the sequence from angry (happy) face. In order to understand the processing of dynamic facial expressions, we examined how direction, intensity range, and velocity of the sequence affect the shift. In each trial, the observers rated the emotional intensity of the last face in the sequence of dynamic facial expression in one of the three emotions (happy, angry, and surprise). We found that the shift for the sequence from strong intensity of expression to neutral face was larger than that for the sequence with opposite direction, and that the shift for the sequence toward the middle intensity was larger than that for the sequence to the neutral face or to strong intensity. These results suggest that disappearing direction and specific intensity range would enhance the overshooting in the processing of the dynamic facial expressions.

◆ **Response properties of visual areas that are responsive to fearful scenes**

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Previous studies have mainly investigated neural correlates of affective perception by using complex stimuli such as faces and scenes, whereas only a few recent studies looked at whether simple shapes, such as a downward pointing triangle, could lead to threatening perception (Larson et al, 2008 *Journal of Cognitive Neuroscience* 21(8), 1523–1535). It is unknown whether and how low- and mid-level visual features may modulate response functions of the visual areas that are responsive to complex emotional stimuli. By contrasting fMRI activation corresponding to an independent set of fearful scenes versus scrambled images, we first localized regions of interest (ROIs) in bilateral fusiform gyrus (FG) and lateral occipital cortex (LOC). We then applied an event-related design to investigate response properties of these ROIs as a function of roundness, orientation, and contrast polarity of stimuli that consist of simple shapes. Further, we investigated whether brain activation induced by the simple shapes may be modulated by adding schematic facial contexts. Whereas activity in LOC was modulated by both shape and facial context, activity in FG was only modulated by facial context. We didn't find any effect of contrast polarity. These mixed results suggest different functional roles of LOC and FG in affective perception.

◆ **Mud sticks: How biographical knowledge influences facial expression perception**

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Although our ability to process facial expression is a crucial factor in human relations and communication, we know little about the way our knowledge of people influences the way we process their expressions. In this study, participants were trained for a week to memorise short biographical vignettes depicting benevolent or malevolent characters, paired with neutral faces. They were aware of their fictitious nature from the start of the experiment. We used fMRI to acquire whole-brain images from participants viewing the character faces with happy, neutral or angry expressions. The amygdala responded differentially to faces of the individuals portrayed as benevolent and malevolent. Furthermore, behavioural testing demonstrated that participants were significantly faster to categorise the emotion of a face when the expression was congruent with the vignette (eg, angry expression and malevolent character). These results indicate that prior knowledge of character traits of an individual has an effect on the way we perceive facial expressions. They also suggest that the amygdala could be involved in higher cognitive functions than sensory-based emotions, and affected by our emotional memory.

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◆ **Behind every strong man there is a strong background: The effect of dynamic background textures on facial evaluation**

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Human evaluation of facial expressions is significantly affected by the emotional context of the visual background (Koji and Fernandes, Can, 2010 *Journal Experimental Psychology* **64**(2) 107–116). We recently found that dynamic visual textures elicit a wide range of emotional responses, with dominance (strength or conspicuity) being one of the principal affective dimensions (Toet et al, 2012 *i-Perception* **2**(9), 969–991). In the current study we investigate whether dynamic textured backgrounds also affect the judgment of human facial expressions. Participants rated the dominance of 12 (neutral) male faces. In the first experiment we validated the neutrality of these faces by placing them on a neutral (black) background. Results show that none of the faces resulted in a non-zero dominance score. In the second experiment the faces were overlaid (opacity 80%) on 12 different natural dynamic background textures, six of which were very strong/conspicuous and six which were very weak/inconspicuous. The results show that the (neutral) faces were rated significantly more dominant on strong/conspicuous backgrounds than on neutral backgrounds. There is no significant difference between ratings obtained with weak/inconspicuous backgrounds and with neutral backgrounds. We conclude that natural dynamic backgrounds (typically not perceived as emotional) can significantly affect the evaluation of facial expressions.

◆ **The angry face advantage in the visual search task is derived mainly from the efficient rejection of distractors**

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Many studies have reported that angry faces should be detected faster than any other emotional faces. Current study, using schematic and photographic stimuli, reexamined the detection efficiencies of angry and happy faces in the visual search task. The results showed that, for schematic stimuli, angry faces were detected faster than happy faces irrespective of emotions of distractors, suggesting the angry face advantage. However, there was no difference in detection efficiency between angry and happy targets among neutral distractors when photographic faces were used. Furthermore, in target absent conditions, there were substantial differences between two stimulus classes. For schematic stimuli, neutral distractors were rejected faster than happy distractors, which in turn were rejected faster than angry distractors. Accordingly, whereas angry targets among neutral distractors were detected most rapidly, the detection of happy targets among angry distractors was the slowest. For photographic faces, happy distractors were rejected faster than neutral distractors, which in turn were rejected faster than angry distractors; while angry faces were detected most efficiently among happy distractors, happy faces were detected most slowly among angry distractors. These results suggested that the angry face advantage in the visual search task should be derived mainly from the efficient rejection of distractors.

◆ **Neural correlates of perceptual learning of objects in the hippocampus and the dorsolateral prefrontal cortex**

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Perceptual learning is the improvement in a perceptual task through repeated training or exposure, typically during the course of several days or weeks. In this study we investigate reward-dependent perceptual learning of object recognition. Human subjects had to recognize briefly presented and backward-masked objects over the course of five days. On days 2 to 4 subjects received either high-reward or low-reward feedback on their choices (training phase). On days 1 and 5 they performed the task inside the fMRI scanner, without feedback, to compare pre- and post-training fMRI activity. Each object belonged to one of three category pairs, one of which was omitted in the training phase (control category pair). Behaviorally we find that the subjects' performance improved significantly more for trained compared to control categories with an additional advantage for high-rewarded stimuli. fMRI data analysis revealed a neural correlate of perceptual learning in the posterior hippocampus. This hippocampal activation was sensitive to the reward magnitude and was paralleled by an increased frontostriatal activation for high versus low reward. Additionally activity in the dorsolateral prefrontal

cortex was strongly modulated by the inter-subject variability of the behavioral improvement, potentially reflecting enhanced clarity of perceptual decisions through training.

◆ **Relationship between visuotactile and affective/aesthetic qualities of natural materials**

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We have recently shown that human ventral visual cortex represents natural material categories (eg, metal, wood and fur) in a way reflecting their visual and tactile qualities such as smoothness and hardness (Hiramatsu et al, 2011, *NeuroImage* **57** 482–494). Seeing materials evoke not only visuotactile feelings but also affective and aesthetic feelings—we feel furry objects comfortable and seeing a log cabin may make us feel relaxed. What neural/psychological processes underlie the emergence of such affective/aesthetic feelings? To understand this, we examined visuotactile and affective/aesthetic qualities for CG images of nine natural material categories using a semantic differential method with >30 adjective-pairs. We found that inter-individual correlation of the rating can be a good measure to define a set of scales that characterize affective/aesthetic qualities: ratings with adjectives such as hard-soft were highly consistent across participants whereas those such as beautiful-ugly tended to differ among participants. With this objective measure, we separately evaluated affective/aesthetic and visuotactile qualities of the materials, each of which was represented as a multidimensional space. The structure of those spaces differed but could be related by simple transformations. We present a model predicting affective/aesthetic qualities of materials from their visuotactile qualities.

POSTERS: FACE PROCESSING

◆ **Linking face-spaces for emotion and trait perception**

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Physiognomic features that resemble an emotional expression give rise to trait impressions like those elicited by the emotion, which has been called an emotion overgeneralization effect (Zebrowitz, 1997, *Reading Faces*, Boulder, CO, Westview Press; Zebrowitz and Montepare, 2008, *Soc Pers Psychol Compass*, **2/3** 1497–1517). For example, the subtle similarity of neutral faces to happy and angry expressions, respectively, disposes us to perceive that a person should be approached and avoided, resulting in trustworthy and untrustworthy impressions (Oosterhof and Todorov, 2008, *Proc Natl Acad Sci USA* **105**, 11087–11092). In this study, we examined the emotion overgeneralization effect by analyzing how the major dimensions of emotion perception (ie, pleasantness and arousal; Russell and Bullock, 1985, *J Pers Soc Psychol* **48**, 1290–1298) and trait perception (ie, trustworthiness and dominance; Todorov et al, 2008, *Trends Cogn Sci* 455–460) are related with one another. A total of 150 neutral faces were rated by 443 participants. Results showed that pleasantness and arousal were both correlated positively with trustworthiness, while they were respectively correlated negatively (although weakly) and positively with dominance. Our findings suggest a close but possibly oblique relationship between face-spaces for emotion and trait perception.

◆ **Age-related contextual modulation in face recognition**

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Social exchanges rely on efficient recognition of potential cooperators and cheaters. A previous study showed that face recognition can be modulated by the social context during encoding (Felisberti and Pavey, 2010, *PLoS One*), but possible aging effects are not known. Here behavioural descriptors were tagged to faces in a scenario involving money exchanges during memorization. The three descriptors contained no rules of the social contract and no moral values (cheating, cooperation or neutral behaviours were implicit). Participants ($N=170$) had to complete an old/new recognition task. Results showed an increase in false alarms and reaction time with age. Hit rates and sensitivity to faces of ‘cooperators’ were higher than for ‘cheaters’ in both young (<30 years) and old (>55 years) adults. Differences between cooperators and cheaters were attenuated when the person lending money to hypothetical friends changed from an unknown person to the participants themselves, but reaction time was still longer for cheaters. Although seniors might have been exposed to more cheaters in their lifespan, cheaters’ recognition was not significantly better than in young adults, which suggests an age-invariant contextual bias towards prosocial behaviours in face recognition.

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◆ **Investigating the orthogonality of configural, and holistic processing mechanisms in face recognition**

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There is a lack of consistency in conceptual terminology, as well as debate in the literature, about how the generally accepted processing types in face recognition—featural, configural, and holistic—are to be distinguished from each other. This study compared within subject performance across four seminal face perception tasks thought to tap into either holistic or configural processing mechanisms: face inversion, part-whole, configural/featural difference detection, and composite face identification. This was done in order to determine if, and to what extent, performance among these tasks is related, and therefore how many distinct mechanisms underlie face processing. Each task was implemented as a 2AFC sequential matching paradigm with a 2x2 design. 20 participants were assessed on all four tasks. Correlational analysis indicates that performance on the part-whole task is correlated with performance on the composite face task, suggesting that these tasks do indeed tap into the same holistic processing mechanism. Similarly, performance on the face inversion and configural/featural tasks correlates, suggesting that they tap into a common configural processing mechanism. This analysis provides evidence as to what each of these widely-used tasks is actually measuring, as well as providing evidence for a distinction between configural and holistic modalities in face processing.

◆ **The impact of within-person variability on face perception and identification**

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Psychological studies of face perception have typically ignored within-person variation in appearance, instead emphasising differences between individuals. Studies assume that a photograph adequately captures a person's appearance, and for that reason most studies use just one, or a small number of photos per person. In a simple task participants were given a set of 40 images made up of 20 images of two different males, and were asked to sort the images into 'identities'. With no additional information participants sorted the images finding an average of ten different identities amongst the images instead of two. In subsequent tasks using different images the findings were replicated with additional images of visually similar people, visually dissimilar people and just one person. These findings suggest that photographs are not consistent indicators of facial appearance because they are blind to within-person variability. This observation is critical for our understanding of face processing as well as showing that this scale of variability has important practical implications, for example, our findings suggest that face photographs are unsuitable as proof of identity.

◆ **What facial information is important for rapid detection of the face? Comparative cognitive studies between humans and monkeys**

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Purpose: Based on previous work (Nakata et al, 2011 *Perception* 40 ECVP Supplement) suggesting that participants efficiently detected the faces of their own species in visual search tasks, and that inner features (eg, eyes) of the face were not important for efficiency, this study further explores what contributes to efficient face detection. Method: Subjects were two Japanese macaques and human participants. Stimuli consisted of several types of faces and non-face distracter objects. Subjects were asked to detect an odd element (the face) in an array of distracters (non-face objects) that were of different sizes (4–20). Results and discussion: Both humans and monkeys efficiently detected the face with low spatial frequency components, and the face with which they had fewer visual experiences (the other race faces for humans, and rhesus monkey faces for Japanese macaques); however, they did not efficiently detect the face with high spatial frequency components, the silhouettes of faces, and the back of the heads. These results suggest that the information of low spatial frequency components contained within outer features of their own species face was possibly affected as antecedent information for detecting the face in the face-processing mechanism.

◆ **Reduction of the perceptual field for inverted faces: evidence from gaze contingency with full view stimuli**

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Displaying only the fixated part of a face by gaze-contingency decreases the face inversion effect (FIE) while masking the fixated part increases the FIE (Van Belle et al, 2010 *Journal of Vision*). This

observation indicates that the FIE is due to a difficulty at simultaneously perceiving multiple facial parts present outside of the fixated part, for inverted faces. Here we aimed at directly observing the differential use of central and peripheral information in upright/inverted faces, with faces fully visible. 14 Participants had to match a reference face to one of two simultaneously presented faces in full view (figure 1). The reference face was a combination of the two other faces in a gaze-contingent way. That is, the part in the center of gaze equaled the corresponding part of one of the faces, while the peripheral part equaled the other face. The reference face was updated upon each gaze position shift. The proportion of choices for the answering alternative corresponding to the centrally presented part of the reference face was higher for inverted than for upright faces. These observations confirm the narrower perceptual field of vision for inverted than for upright faces, supporting a decreased holistic processing for inverted than upright faces.

◆ **Right perceptual bias and self-face advantage in congenital prosopagnosics**

134 M Malaspina, A Albonico, R Daini (Psychology Dept, Università degli studi di Milano-Bicocca, Italy; e-mail: manu.malaspina@gmail.com)

Left perceptual bias refers to the tendency to base our judgments more on the right half-part of face (Gilbert and Bakan, 1973 *Neuropsychologia* **11**(3) 355–362), while self-face advantage consists in a faster response in recognizing our own face, suggesting different processing for our and others' faces (Keenan et al, 1999 *Neuropsychologia* **37**(12) 1421–1425). The aim of this study was to verify the existence of an interaction between these two perceptual effects in normal and dysfunctional conditions, allowing us to better understand mechanisms underlying psychophysiological processing of faces. In particular reaction times and accuracy were recorded from 13 subjects with congenital prosopagnosia and 13 subjects with typical development, matched by age and sex, during matching task involving chimeric stimuli depicting their and others' faces. Both groups showed a better performance in recognizing their own face than the others' faces, suggesting the consistency of the self-face advantage. Moreover, while the control group had a higher accuracy when their own left half-face fell to the left side of chimeric stimuli, the experimental group showed a better performance when their own right half-face fell to the right (right-perceptual bias), suggesting for these subjects a different lateralization in face processing.

◆ **The face of terrorism: Stereotypical Muslim facial attributes evoke implicit perception of threat**

135 G Harsanyi, M Raab, V M Hesslinger, D Düelos, J Zink, C C Carbon (Dept of General Psychology and Methodology, University of Bamberg, Germany; e-mail: ccc@experimental-psychology.com)

Al-Qaida's founder Osama bin Laden wore highly iconic paraphernalia (Carbon, 2008 *Perception* **37**(5) 801–806), namely a turban and a characteristic beard. As the media consistently presented him in this distinctive style, his outward appearance formed a visual stereotype of Islamist terrorists that, in most cases, did not match the appearance of Islamist assassins. Using the multidimensional Implicit Association Test (md-IAT, Gattol et al, 2011 *Plos One* **6**(1) e15849) we tested the effect of adding accordant stereotypical paraphernalia to male Caucasian faces ('Muslim-version'): Compared to the original, non-manipulated versions, the 'Muslim-versions' were evaluated as being more irrational, unintelligent, unreliable and, particularly, as being more dangerous. Importantly, non-psychologists' and psychologists' data did not show any significant difference concerning these implicit measures but did so for explicit measures assessed by a further test. This dissociate data pattern demonstrates that iconic presentations elicit stereotypical associations independently of explicit reports. We argue that visual attributes like a particular kind of beard and a turban are associated with conformity to Islam, which is again associated with terrorist threat. More generally, the results suggest that the mere presence of visual attributes can induce implicit black-and-white categorization and undifferentiated prejudice toward people of other cultures.

◆ **Contrast reversal of the eyes diminishes infants' face processing**

136 H Ichikawa¹, Y Otsuka², S Kanazawa³, M K Yamaguchi⁴, R Kakigi⁵ (¹Chuo University and JSPS, Japan; ²University of New South Wales, Australia; ³Japan Women's University, Japan; ⁴Chuo University, Japan; ⁵National Institute for Physiological Sciences, Japan; e-mail: ichihiro@tamacc.chuo-u.ac.jp)

The contrast polarity relationship between sclera and iris is important for face recognition. Gilad et al (2008 *Proceedings of the National Academy of Sciences of the USA* **106** 5353–5358) reported that the contrast polarity around eyes (darker eye region) is critical for familiar face recognition and for FFA activation in adults. Otsuka et al (under review) have reported that 7- to 8-month-olds discriminate

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between faces only when the contrast polarity of the eyes is preserved, irrespective of the contrast polarity of the rest of the face. In the present study, we investigated the effect of contrast polarity of eyes on face related neural activity in infants by using near-infrared spectroscopy (NIRS). We measured hemodynamic responses in bilateral temporal area of 7- to 8-month-old infants. The hemodynamic responses to faces with positive eyes and those with negative eyes were compared against the baseline activation during the presentation of object images. We found that the presentation of faces with positive eyes increased the concentration of oxy-Hb and total-Hb in the right temporal area compared to baseline, while no such change occurred for the presentation of faces with negative eyes. Our results suggest the importance of contrast polarity of eyes in the face selective neural responses from early in the development.

◆ **Contribution of cardinal orientations to the “Stare-in-the-crowd” effect**

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Evidence showed that the processing of face identity relies on horizontally-oriented cues, with little contribution of vertically-oriented cues. Besides identity, faces convey a wealth of fundamental social cues such as gaze. We investigated whether the processing of gaze is tuned to horizontal orientation as observed for identity. Participants were presented with arrays of six faces and instructed to search for a target face with either direct gaze (DG) or averted gaze (AG). The “stare-in-the-crowd” effect refers to the observation that DG is more easily detected than AG. Faces were filtered to preserve a 20°-orientation range centered either on horizontal or vertical orientation (H and V condition, respectively). In a third condition, horizontal plus vertical information was preserved (HV) by summing the H and V filtered images. Our results replicate the “stare-in-the-crowd” effect; namely, detecting DG was overall more accurate and faster than detecting AG. More importantly, the “stare-in-the-crowd” effect was significant only for vertically-filtered faces, in trials where a DG target was present. The same pattern was observed on RT. These findings suggest that although horizontal information is central for the processing of face identity, vertical information contributes to the processing of some core social signals conveyed by faces.

◆ **Psychological distance and face recognition: thinking about own local place impairs face recognition**

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This study investigated the effect of psychological distance on face recognition. According to “Construal Level Theory” (Lieberman and Trope, 1998), thinking about proximal distance event activates featural information. If so, the activation may evoke featural processing that would be carried over to the face recognition task. The featural processing is also said to decrease accuracy of face recognition. Because previous work found that proximal temporal distance impaired face recognition (Wyer, Perfect, and Pahl, 2010), we predicted that proximal spatial distance also impaired face recognition. Participants ($N=64$) were randomly assigned to one of the three conditions (near distance, far distance, control). Participants in all condition watched the video depicting crime. After watching the video, participants in the near distance condition imagined what they did in their local place whereas participants in the far distance condition imagined what they did in a foreign country. Participants in the control condition were assigned the filler task. Finally, all participants took a face recognition test. The accuracy of face recognition in the near distance condition was significantly lower than that in the far distance and control condition. This result supported that psychological spatial distance influenced facial memory.

◆ **Facial distinctiveness is affected by facial expressions**

139 T Nozomi, H Yamada (Nihon University, Japan; e-mail: kan@chs.nihon-u.ac.jp)

Bruce and Young’s (1986) model posited that the processes underlying facial identity and facial expression recognition are independent. However, recent studies have shown some possible interactions between those processes (eg Schweinberger and Soukup, 1998 *Journal of Experimental Psychology* **24**(6) 1748–1765; Fox et al, 2008 *Journal of Vision* **8**(3) 1–13). Relating to this issue, we examined whether facial distinctiveness is affected by facial expressions. We used 168 images of twenty person’s face (twelve males) with neutral and six facial expressions (happiness, surprise, fear, sadness, anger and disgust) as stimuli. Seventy participants were randomly assigned to one of seven groups, in which ten participants rated each of 24 different faces with the same one of six facial expressions or neutral in terms of how easy they think the person would be to spot in a crowd on an 8-point Likert scale. The results showed that mean distinctiveness ratings of neutral faces were highly and significantly correlated

with the ones of their happy faces but not with their sad faces, indicating that happy face could keep or maintain the distinctive properties of neutral face but sad face does not. We will discuss the plausible interactions between facial identity and facial expression recognition based on these results.

◆ **Attractiveness enhances the perceived familiarity of unfamiliar faces but not familiar faces**

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Previous research has indicated that the perceived familiarity of an unfamiliar face is positively correlated with the attractiveness of the face and that brief exposure to previously unfamiliar faces increases the strength of this correlation (Peskin and Newell, 2004 *Perception* **33** 147–157). In addition, the familiarity ratings of even highly familiar faces are influenced by the expression of the face with positive expressions yielding higher familiarity ratings (Lander and Metcalfe, 2007 *Memory* **15** 63–69). In the study reported, we attempted to establish whether the perceived familiarity of both familiar and unfamiliar faces is affected by the attractiveness of the face. Participants were shown four groups of faces (familiar attractive, familiar less-attractive, unfamiliar attractive, unfamiliar less-attractive) and were asked to rate each face for familiarity. The results indicated that attractiveness had an effect on the perceived familiarity of unfamiliar faces with attractive unfamiliar faces being rated significantly more familiar than less-attractive faces. No difference was found for the familiarity ratings of familiar faces. The results indicate that unlike expressions, attractiveness does not influence the perceived familiarity of familiar faces. It is suggested that non-changeable aspects of a face (such as attractiveness) do not influence familiarity once a face is sufficiently familiar.

◆ **Can a test battery reveal subgroups in congenital prosopagnosia?**

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Congenital prosopagnosia, the innate impairment in recognizing faces exhibits diverse deficits. Due to this heterogeneity the possible existence of subgroups of the impairment was suggested (eg Kress and Daum, 2003 *Behavioural Neurology* **14** 109–21). We examined 23 congenital prosopagnosics (cPAs) identified via a screening questionnaire (as used in Stollhoff, Jost, Elze, and Kennerknecht, 2011 *PLoS ONE* **6**e15702) and 23 age-, gender and educationally matched controls with a battery consisting of nine different tests. These included well known tests like the Cambridge Face Memory Test (CFMT, Duchaine and Nakayama, 2006 *Neuropsychologia* **44** 576–85), a Famous Face Test (FFT), and new, own tests about object and face recognition. As expected, cPAs had lower CFMT and FFT scores than the controls. Analyses of the performance patterns across the nine tests suggest the existence of subgroups within both cPAs and controls. These groups could not be revealed only based on the CFMT and FFT scores, indicating the necessity of tests addressing different, specific aspects of object and face perception for the identification of subgroups. Current work focuses on characterizing the subgroups and identifying the most useful tests.

◆ **Classifying faces as faces: effects of identity and expression strength**

142 A Skinner, C Benton (University of Bristol, UK; e-mail: andy.skinner@bristol.ac.uk)

A variety of different experimental approaches have provided evidence that visual representations of facial identity are coded in a multi-dimensional face space. Recently, adaptation studies have suggested facial expression might be represented this way too. Here, we explored this apparent similarity between the representations of identity and expression by returning to look again at the effect distinctiveness has on our ability to classify visual stimuli as faces—one of the phenomena that originally inspired the development of the multi-dimensional face space model. For the first time we compared the effects variations in distinctiveness (now achieved by varying the strength of caricaturing) of both identity and expression have on our performance classifying faces as faces. We replicated previous findings showing it takes longer to classify faces with distinctive (higher strength) identities as faces, in line with the predictions of face space. Crucially, we observed the same pattern of results for expressions. Our findings provide new evidence that identity and expression are represented in a similar manner. This aligns with an emerging view in which visual representations of identity and expression are not separate, and may exist within a single representational framework.

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◆ **The time course of chromatic and achromatic information extraction in a face-gender discrimination task**

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A previous study using the Bubbles technique (Dupuis-Roy, et al, 2009) showed that the eyes, the eyebrows, and the mouth were the most potent features for face-gender discrimination (see also Brown and Perrett, 1993; Russell, 2003, 2005; Yamaguchi, Hirukawa, and Kanazawa, 1995). Intriguingly, the results also revealed a large positive correlation between the mouth region and rapid correct answers. Given the highly discriminative color information in this region, we hypothesized that the extraction of color and luminance cues may have different time courses. Here, we tested this possibility by sampling the chromatic and achromatic face cues independently with spatial and temporal Bubbles (see Gosselin and Schyns, 2001; Blais et al, 2009). Fifty participants (25 men) completed 900 trials of a face-gender discrimination task with briefly presented sampled faces (200 ms). To create a stimulus, we first isolated the S and V channels of the HSV color space for 300 color pictures of frontal-view faces (average interpupil distance of 1.03 deg of visual angle) and adjusted the S channel so that every color was isoluminant ($\pm 5 \text{ cd m}^{-2}$); then, we sampled S and V channels independently through space and time with 3D Gaussian windows (spatial std = 0.15 deg of visual angle and temporal std = 23.53 ms). The group classification image computed on the response accuracy shows that in the first 60 ms, participants used the color in the right eye-eyebrow and mouth regions, and that they mostly relied on the luminance information located in the eyes-eyebrows regions later on (>60 ms). Preliminary results also suggest that the time-course of the extraction of chromatic information differs slightly between male and female observers. Altogether, these results help to disentangle the relative contributions of chromatic and luminance information to face-gender discrimination.

◆ **The McGurk effect is not affected by face orientation**

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The well known McGurk effect (McGurk and MacDonald, 1976 *Nature* **264** 746–748) has incongruent audio-visual speech stimuli, the visual lip-movements affect the perception of the auditory stimuli so that a different sound from the stimulus-sound is perceived or “heard”. The visual lip movements of Ga dubbed with the audio of Ba, gives the percept of Da. Various workers have reported that the effect is less strong when the face is presented at angles which are not upright (Jordan and Bevan, 1997 *Journal of Experimental Psychology: Human Perception and Performance* **25** 388–403). We investigated this further at 8 different angles 0, 45, 90, 135, 180, 225, 270, 315. 30 participants were tested with 4 different incongruent stimuli such as Ga-(vis) with Ba-(aud). If the response was Da it was classified as a “McGurk” and if as a Ba it was classified as a correct audio response. Eye tracking was recorded to check for attention. No main effect of orientation was found although there were highly significant differences between the incongruent stimuli. The results will be discussed with reference to brain processing for face recognition and speech reading.

◆ **Neural correlates of eye contact and the Mona Lisa effect**

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Perception of eye contact and averted gaze activate distinct behavioral and cognitive mechanisms and might be processed by dissociable brain networks. Gamer and Hecht (2007) proposed the metaphor of a cone of gaze to describe the range of gaze directions within which a person feels looked at. The width of the gaze cone is about nine degrees of visual angle. Thus, neural activation patterns should differ depending on whether a gaze is directed straight at the viewer, at the edge of the gaze cone, or if it is clearly averted. We conducted an fMRI study to locate the brain regions involved in mutual gaze detection, presenting portraits with varying gaze directions. An irrelevant task was added to ascertain that subjects looked at the portrait's eyes. Moreover, the portraits were presented at central and laterally displaced positions. Real heads stop to make eye contact when displaced laterally, however, portrait heads continue gaze at the observer. This is the so called Mona Lisa effect, which is remarkably robust and breaks down only at extremely oblique vantage points. We hypothesized that the same brain areas process gaze in physical and pictorial situations. The cortical activation patterns were found to differ depending on vantage point.

◆ **Abnormal response-dynamics of face-related areas in congenital prosopagnosia**

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Congenital prosopagnosia (CP) is a life-long disorder of face perception. We investigated the neural bases of CP in three patients of a family (father, daughter and son), as well in healthy, age-matched controls, using combined neuropsychological, electrophysiological and functional magnetic resonance imaging (fMRI) methods. Neuropsychological tests demonstrated significant impairments of face perception/recognition in each patient. To reveal the impairments of the core face processing network we presented faces and nonsense objects in a block-design experiment to the patients and to a control group in the fMRI scanner. We found that the activity of the fusiform and occipital face areas (FFA, OFA) was reduced, when compared to controls, but remained category-selective. Analysis of the hemodynamic response function, however, revealed a significantly faster and stronger adaptation in all areas (FFA, OFA and the lateral occipital cortex) in the CP patients when compared to controls. Our results emphasize the dysfunction of the core system in CP. Further, it suggests that it is not the magnitude of activation, rather the response dynamics that lies behind the impairments of face perception in CP. [This work is supported by The Hungarian Scientific Research Fund (OTKA) PD 101499 (M Z).]

◆ **Evidence of a size underestimation of upright faces**

147 Y Araragi¹, T Aotani², A Kitaoka² (¹Shimane University and Ritsumeikan University, Japan; ²Ritsumeikan University, Japan; e-mail: uqa@soc.shimane-u.ac.jp)

We quantitatively examined the difference in perceived size between upright and inverted faces using the method of constant stimuli. The stimuli included seven face images modified from two cartoon faces produced by Kitaoka (2007; 2010) and five photographic faces. Experiment 1 showed that upright faces were perceived to be significantly smaller than upright and inverted outlines, whereas inverted faces were not perceived to be significantly larger than upright or inverted outlines using two cartoon face stimuli. Experiment 2 showed that upright faces were also perceived to be significantly smaller than inverted faces using five photographic face stimuli. These results provide quantitative evidence for a size underestimation of upright faces.

◆ **Head size illusion: head outlines are processed holistically too**

148 K Morikawa, K Okumura, S Matsushita (School of Human Sciences, Osaka University, Japan; e-mail: morikawa@hus.osaka-u.ac.jp)

We investigated a novel facial illusion called the head size illusion. When the lower half outline of a face (ie the contour of cheeks and jaw) is wider or narrower than average, the upper half outline (ie the head contour above eyes) also appears wider or narrower than it really is, respectively. We used the staircase procedure to measure the illusion magnitude. We found that the illusion decreases by half when faces are inverted so as to selectively disrupt holistic processing. The illusion also decreases by half when the internal features (ie eyes, nose, and mouth) of faces are erased. These experiments showed that at least 50% of the head size illusion depends on holistic perceptual processing of faces per se. It is well known that facial features (ie eyes, nose, and mouth) are processed holistically. The head size illusion demonstrates that head outlines are also processed holistically because the lower half outlines influence perceived shape of the upper half outlines. This phenomenon may be an example of a new class of illusions called "biological illusions".

◆ **The retrieval of semantic and episodic information from faces and voices: A face advantage**

149 C Barsics, S Brédart (University of Liege, Belgium; e-mail: c.barsics@ulg.ac.be)

Recent findings indicate that semantic and episodic information is more likely to be retrieved from faces than voices (Damjanovic and Hanley, 2007 *Memory and Cognition* **35**(6), 1205–1210). Previous studies investigating this 'face advantage' over voice used famous faces and voices as stimuli, which induced several methodological difficulties. We present four studies aimed at further examining the differential retrieval of semantic and episodic information from faces and voices. Study 1 and 2 compare the retrieval of semantic and episodic information from pre-experimentally personally familiar faces and voices (Brédart, Barsics, and Hanley, 2009 *European Journal of Cognitive Psychology* **21**(7), 1013–1021; Barsics and Brédart, 2011 *Consciousness and Cognition* **20**(2), 303–308). In study 3, an associative learning paradigm is used in order to strictly control the frequency of exposure with faces and voices. The recall of semantic information is subsequently assessed from faces and voices. In study 4, distinctiveness

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impact on semantic information retrieval from faces and voices is assessed, as it could constitute a key factor underlying the face advantage over voice. All results are in line with the face advantage. These findings are discussed at the light of current models of person recognition. An account in terms of expertise is finally proposed.

◆ **Different facets of facial attractiveness: Specification of the relationship between attractiveness, beauty, prettiness and sexual attraction**

150 R A Luedtke, V M Hesslinger, C C Carbon (Dept of General Psychology and Methodology, University of Bamberg, Germany; e-mail: ramona.luedtke@ymail.com)

Research on facial attractiveness repeatedly reveals high correlations between ratings of attractiveness, beauty, prettiness, and sexual attraction. However, attempts to define their specific relationship as facets of a superordinate concept of attractiveness and to draw precise distinctions between the corresponding terms are sparse. Employing 80 faces per sex presented in two different modes the current experiment addressed both aspects: In the blockwise condition, the faces were presented successively and rated in four separate blocks (one block per variable). In the sequential condition, each face was presented four times in a row and rated for all variables before the next stimulus was displayed. Besides a high consistency for the assessment of the variables, we found an effect of presentation mode with the sequential condition leading to significantly higher correlations. Apparently, participants proceed in a more economic fashion by reducing cognitive effort when the situation allows it. Moreover, results show that prettiness is a good predictor for beauty whereas attractiveness is mainly predicted by sexual attraction when stimuli are presented blockwise. Integrating these findings and common theoretical accounts concerning the comprised variables the present study qualifies their usage and asks for clearer definitions in research dealing with these variables and associated constructs.

◆ **On the plausibility of a generalized model of perceived similarity between faces**

151 L Lorusso¹, G Brelstaff², L Pulina¹, E Grosso¹ (¹University of Sassari–Dept of Political Science, Communication and Computer Engineering, Italy; ²CRS4, Italy; e-mail: lorusso@uniss.it)

Is there consensus among observers about which faces are seen as similar, or do large individual variations across observers occur? We test the plausibility of a generalized model of perceived visual similarity between faces as opposed to an individualized, subject-dependent model (cf Simmons and Estes, 2008 *Cognition* 108 781–795). Unlike previous studies, we avoid the use of ratings to measure perceived face-pair similarity and instead adopt a direct comparison task between sets of face-pairs. We use a two-alternative forced choice (2AFC) protocol where the observers must choose between two candidate face-images by indicating which looks the most similar to a third. Each observer completes a randomized sequence of 2AFC trials whereby a small set of face-pairs gets fairly compared in similarity against our data-set of 54 different face-images. Degrees of similarity, derived from a statistical analysis of the results, indicate a high degree of consensus among observers, boosting the plausibility of a generalized model of perception of similarity. A preliminary extension of this analysis to known subclasses of face-images related by sex, age or kinship, may reveal insights about the structure of that model.

◆ **Forty years later: Are objects still mentally rotated as in 1971?**

152 C C Carbon, F Diener Rico (University of Bamberg, Germany; e-mail: ccc@experimental-psychology.de)

In 1971, a groundbreaking paper published by Shepard and Metzler put forward the idea that 3D-objects are “mentally rotated” when perceived in an orientation deviated from upright. Referring to clear empiric evidence given by this seminal contribution, the theory of mental rotation states that reaction times required for matching two objects follow a linearly increasing function of the angular difference between the respective objects’ orientations. Accordant inferences are limited by the fact that (1) only same-matching trials were considered and that (2) correct rates were neglected. We conducted a replication using the original material (Tetris-like 3D-objects) plus further stimulus classes of varying complexity: houses (low), greebles (medium) and faces (high) with different-matching trials presenting the referring stimulus together with a thatcherised analog. For 3D-objects, the proposed linear RT trend emerged for same-matching, but not for different-matching trials. Furthermore, a strong linear increase of errors (from error-free to near-to-chance) for same-matching trials suggests that the linear RT trend could alternatively be described as a speed-accuracy tradeoff artifact. For faces, a linear RT trend was not found, which indicates, in line with Carbon et al (2007 *Perception* 36 1635–1645), that matching of more complex stimuli is based on more sophisticated, multifaceted processing.

◆ **Do you sound or look as old as you are? A study of age estimation in young and older adults**

153 E Moyses, A Beaufort, S Brédart (University of Liège, Belgium; e-mail: evelyne.moyse@ulg.ac.be)
Studies on age estimation usually indicated that people are fairly accurate at estimating the age of a person from her/his face or from her/his voice (with an absolute difference of five and ten years respectively) (eg Amilon et al, 2000, in *Speaker Classification II. Lectures Notes in Artificial Intelligence* C Müller, Berlin, Springer-Verlag). However studies showed also that performance depends on the age of participants and the age of stimuli (Rhodes, 2009 *Applied Cognitive Psychology* **23** 1–12; Braun, 1996 *Forensic Linguistics* **3** 65–73). The aim of the present study is to compare age estimation performance from faces and voices by using an experimental design in which the age of participants (young vs older), the age of stimuli (young vs older) and the stimulus domain (face vs voice) were crossed. Overall, the age of faces was more accurately estimated than the age of voices. Moreover performance of age estimation was better for young stimuli than for older stimuli. Finally, young participants made smaller absolute errors than older participants. However, there is no difference between young and older participants when estimating the age of older stimuli.

◆ **Spatial configuration of faces and Japanese characters differently affects perceptual dominance in binocular rivalry**

154 E Kimura¹, A Hidaka², K Goryo² (¹Chiba University, Japan; ²Kyoto Women's University, Japan; e-mail: kimura@L.chiba-u.ac.jp)

Perceptual dominance in onset rivalry (binocular rivalry between brief stimuli) can be modulated in a stimulus-specific fashion by presenting a binocular preceding stimulus. Analyzing the properties of the dominance modulation can provide insights into how different types of stimulus are represented in the visual system. This study investigated onset rivalry between familiar stimuli, ie, face images and Japanese Kana characters, focusing on the processing of spatial configuration. The rivalrous test stimulus was a pair of either an upright or inverted (180° rotated) stimulus. The binocular preceding stimulus was the same as one half-image, but its orientation was manipulated (upright or inverted). Results showed distinctive patterns of dominance modulation for face and Kana stimuli. For face stimuli, the modulation was asymmetric. The upright preceding face phenomenally suppressed the same test face regardless of orientation, although the cross-orientation modulation was weaker. In contrast, the inverted preceding face produced little, if any, cross-orientation modulation. However, for Kana stimuli, the modulation was symmetric. The upright preceding character phenomenally suppressed the same upright test character more strongly than the inverted one, and vice versa. These results suggest that Kana characters and face stimuli are represented differently in terms of spatial relationship among local image elements.

POSTERS: MOTION PROCESSING

◆ **Motion processing behind occluders**

155 L Battaglini, G Campana, C Casco (University of Padua, Italy; e-mail: luca.battaglini@studenti.unipd.it)

Can our brain compute motion when a moving target is occluded by another object as a tunnel? De Lucia and Liddel 1998 suggested two different hypothesis: (1) estimation of occlusion time and counting to predict the time to contact (TTC) between the target and the end of the tunnel, (2) extrapolate the motion behind the occluder maintaining active the speed information. Observers compared either the speed (when non occluded) or the TTC (when occluded) of moving stimuli differing in contrast or size. Our results showed that, in agreement with the literature, smaller or higher contrast stimuli were perceived as moving faster, but the major result showed that the TTC was shorter with these stimuli. This indicates that the perceived speed influences the elaboration of motion once occluded, thus supporting the perceptual hypothesis.

◆ **Temporal characteristics of perceived non-overlap of objects in audiovisual stream/bounce displays**

156 Y Kawachi, Y Matsue (Kansei Fukushi Research Institute, Tohoku Fukushi University, Japan; e-mail: kawachi@tfu-mail.tfu.ac.jp)

In a stream/bounce display in which two identical visual objects move toward each other, coincide (overlap), and then move apart, the objects can be perceived as either streaming through or bouncing off each other. Our previous report (Kawachi, 2011 *i-Perception* **2**(8), 834) demonstrated a perceptual phenomenon in which the presentation of a brief tone at the coincidence point promoted the perception of a non-overlap and of the objects bouncing off each other. In the present study, the amount of overlap

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between two objects and the temporal offset between the overlap and the tone presentation (0, ± 90 ms, and ± 390 ms) were parametrically manipulated. Observers were first asked to judge whether the two objects overlapped with each other and then asked whether the objects appeared to stream through or bounce off each other. When the tone was presented at and before the overlap, the perception of a non-overlap and of the objects bouncing off each other was stronger than when the tone was presented after the overlap. Together with the results of a supplementary experiment on task-relevant selective attention to a visual event, we discuss how an abrupt auditory stimulus temporally modulates visual processing in a stream/bounce display.

◆ **Anisotropy in postural sway caused by optic-flow: a matter of co-contraction?**

157 V Holten, M J van der Smagt, S F Donker, F A Verstraten (Utrecht University, Netherlands; e-mail: v.holten@uu.nl)

Previous research showed that contracting radial optic-flow patterns generate more sway than expanding patterns (Wei et al, 2010 *Journal of Vision* **10**(14):4, 1–10). The origin of this (expansion vs contraction) anisotropy is still unknown. Since expanding patterns are more commonly experienced when moving through the environment, the lesser sway for this condition might be related to anticipatory co-contraction of antagonist lower leg muscles. To investigate this, we presented radial random-dot optic-flow patterns to participants, standing on a force-plate in a completely dark room. Simultaneously, electromyography (EMG) from the tibialis anterior and the gastrocnemius was recorded. Optic-flow stimuli (duration 4s) were interleaved by dynamic visual noise patterns (duration varied between 3.4–4.2s). Postural sway was measured in the anterior-posterior direction. While our results concur with the earlier reported anisotropy in postural sway, we do not observe co-contraction during expanding (or contracting) optic-flow pattern stimulation. Instead, lower-leg muscle activity appears to just follow sway direction, indicating that the (expanding vs contracting) anisotropy in optic-flow induced postural sway is not caused by anticipatory co-contraction of antagonist lower leg muscles.

◆ **Visual traveled distance estimation by leaky integration in driving situations**

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The perception of travel distance in walking range shows characteristic underestimation that can be explained by leaky path integration with gain and leak rate as parameters. We wanted to test whether this is true also in driving, in which distances are much longer and velocities much higher. Thirty subjects drove a multimodal, interactive driving simulator that consisted of a mock car, a 2.80 x 1.60m projection screen, shakers at the car carriage, and vehicle acoustics. In the simulations, subjects drove at speeds up to 160km/h along a straight road with surrounding trees. The experimenter stopped the simulation at specified distances between 500 to 5000m and subjects reported their travel distance estimate in meters. In a second condition, subjects were given a distance number (eg 3500m) and were asked to drive and stop when they felt they reached that distance. The data from both conditions were fit with the leaky integration model. We found participants able to discriminate even long travel distances quite accurately, but with a difference between the two conditions that is characteristic for the leaky integration model. The gain parameter was higher than for walking, whereas the leak rate was smaller for driving than for walking.

◆ **Factors that affect tracking of occluded target motion**

159 A Hughes, M Stevens, D Tolhurst (University of Cambridge, UK; e-mail: aeh60@cam.ac.uk)

In natural scenes, a moving object is very often occluded from view at various points along its trajectory, and it has been shown that humans are able to track invisible target motion created by occlusion. We examined the accuracy of this occlusion tracking using Gabor patches which moved laterally across a CRT before disappearing at the edge of the display; we investigated the effect of the orientation and motion of the stripes within the Gabor. The pattern orientation of the Gabor patch affected the speed judgments, with oblique stripes perceived as moving faster on average compared to vertical or horizontal stripes. Introducing pattern motion within the Gabor patch also caused systematic changes in perceived speed. These changes were in accordance with whether the pattern appeared to be moving forwards or backwards relative to the overall direction of motion; the patches were judged to move faster than a 'no motion' control when the pattern movement was forwards and were judged to move more slowly than a 'no motion' control when the pattern movement was backwards. The findings are discussed in terms of animal camouflage mechanisms and how this research can aid understanding of motion perception in the human visual system.

◆ **Interaction between fine and coarse scales impairs motion discrimination more strongly than surround suppression**

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Ability to discriminate motion direction of a Gabor patch diminishes with increasing size and contrast, indicating surround suppression. Discrimination is also impaired by a static low-spatial frequency patch added to the moving stimulus, suggesting an antagonism between sensors tuned to fine and coarse features. Using Bayesian staircases, we measured duration thresholds in motion-direction discrimination tasks using vertically oriented Gabor patches moving at 2deg/sec. We tested two contrasts (2.8% and 46%) and five window sizes (from 0.7 to 5deg) and two spatial frequencies, 1 c deg⁻¹ and 3 c deg⁻¹, presented either alone or added to a static component. When the moving component was presented alone, duration thresholds increased with size at high contrast, and reduced with size at low contrast. When a 1 c deg⁻¹ moving component was added to a 3 c deg⁻¹ static component duration thresholds were similar to the case when the moving component was presented alone. However, when a moving 3 c deg⁻¹ component was added to a static 1 c deg⁻¹ component duration thresholds increased about four times for high contrast and two times for low contrast. These results suggest that the effect of surround suppression is small compared with the effect produced by the antagonism between sensors tuned to fine and coarse features. [Supported by Grant No. PSI2011-24491 from Ministerio de Ciencia e Innovación (Spain).]

◆ **Development of optic flow sensitivity in school-aged children of Kathmandu**

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The development of sensitivity to optic flow patterns was investigated by measuring motion coherence thresholds (MCTs) in school-aged children in Kathmandu. 119 child observers aged 6–16 years and 24 adult observers (mean age, 23.66 years) participated with informed consent. The observers identified the direction of a translational (rightward vs leftward) and radial (expanding vs contracting) optic flow pattern with 100 dots of 75% (Michelson's contrast) moving at 5.48°/s and 1.56°/s in a 2AFC task. The direction of each dot was drawn from a Gaussian distribution whose standard deviation was either low (similar directions) or high (different directions). MCTs were measured separately for each speed and optic flow pattern. The sensitivity to radial optic flow improved with age, and were still immature at 16 years ($p < 0.05$) at both speeds. All observers had better sensitivity at 5.48°/s compared to 1.56°/s ($p < 0.05$), with difference in developmental pattern for children at these speed. Sensitivity to radial optic flow is immature until late childhood. Differences in sensitivity and development of radial optic flow at two speeds, suggest different motion channels involved in processing slow and fast speeds.

◆ **Apparent duration is compressed for accelerating visual motion**

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Johnston (in Nobre and Coull (eds), *Attention and Time*, 2010) proposed a “predict and compare” clock to explain the effects of adaptive state on the perceived duration of a drifting stimulus. The clock accumulates the number of satisfied (constant velocity) temporal predictions. We might expect an interval containing acceleration should appear expanded, since the stimulus always preempts the prediction. Here we studied the effects of acceleration and deceleration on the perceived duration of a drifting grating. We used several velocity ranges (minimum 0; maximum 67 deg²/s) over three standard durations (300, 600 and 900 ms). The average speed was kept constant (10 °s⁻¹). We found that increasing the velocity progressively reduced perceived duration. However the reduction was proportional to range (independent of standard duration) rather than acceleration. Also the reduction was proportional to the standard length indicating a constant effect through the interval. The results could not be explained by changes in apparent onset or offset. The effects of increases and decreases in speed were highly asymmetric. A decelerating stimulus was subject to a mild dilation that was more pronounced for low rates of deceleration. We suggest acceleration may differentially activate high temporal frequency channels leading to duration compression.

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◆ **Alternation rate dependency of perceptual asynchrony in color-motion binding**

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It has been demonstrated that psychophysical judgments on temporal synchrony of alternating color and motion direction show an apparent delay of motion perception relative to color perception (Moutoussis and Zeki, 1997 *Proceedings of the Royal Society of London B* **264** 393–399). Recent researches showed that the perceptual asynchrony depended on experimental tasks and the alternation rates, and these findings imply that the phenomenon does not simply reflect neural delays of color and motion processes (Nishida and Johnston, 2002 *Current Biology* **12** 359–368). Here we examine what causes the alternation rate dependency of the perceptual asynchrony measured by the pairing task (Clifford et al, 2003 *Vision Research* **43** 2245–2253). To complete the task, observers had to judge durations of individual motions while a stimulus had a certain color, and the apparent delay would be due to a “duration distortion” effect (Kanai and Watanabe, 2006 *Perception & Psychophysics* **68** 1113–1123). The results showed that the alternation rate dependency could not be fully explained by the duration distortion effect and disappeared when another motion signal indicated the periods for judgments. These results suggest that the alternation rate dependency in the pairing task is due to the temporal binding mechanism of different visual features.

◆ **The influence of concomitant pitch perception on timing of a coincidence-anticipation timing task**

164 T Hanai, A Yoshino (Meisei University, Japan; e-mail: t.h.phy.1104@gmail.com)

We examined whether the influence of concomitant pitch perception on timing of a coincidence-anticipation timing task (CAT). A white dot on black background was moved at uniform velocity horizontally from left to right across the center of a 19-inch monitor. The moving speed of the dot was 2 deg / s. The moving dot disappeared between 180 deg and 360 deg from the start of the move. It appeared after the participant's key touch. Vertical lines were displayed in the appearance point and disappearance point. In synchronization with the motion, a sound was played. We presented 16 acoustic conditions. We used 4×4, ie 16 conditions of the animated object moving with all permutations of pairs of the tones 220 Hz, 440 Hz, 880 Hz and silence exchanging after 3 s. The participants were allowed to describe their impressions freely, and they also judged the timing that dot after the occlusion was considered to reach the vertical line by the key touch. As a result, it was observed that concomitant pitch perception increased the error on timing of CAT. It was suggested that concomitant pitch perception affect the timing task of CAT.

TUESDAY

POSTERS: ATTENTION

◆ **Recognition errors in crowding-effect in central vision**

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In central vision we compared the recognition of test stimuli presented in isolation or in the presence of surrounding objects. The stimuli were stylized low-contrast letters having size 1.1, 2.1, or 4.3 deg, and surrounding objects were digits 1–9 of size 1.3 deg. The digits were presented at various distances from the test image. In different experimental sets, participants were asked to identify either the central test stimulus or the both the test and the additional peripheral digit. We found that small separations resulted in a crowding-effect in central vision. Recognition errors in the presence or absence of surrounding objects were compared using correlation analysis and modeling. At small separations, recognition errors were less correlated with the errors to the isolated test (test stimuli presented alone) than were the errors recorded at large separations. In modeling the “distances” between stimuli were calculated using a template model, or a model in which the difference spectra were calculated when the images’ centroids were superposed. The best correlation with the experimental data was obtained with the template model. Our results support the hypothesis that failure of feature integration occurs in the presence of crowding-effect.

◆ **Shifts of visuospatial attention in perihand space**

² M Grosjean, N Le Bigot (Leibniz Research Centre for Working Environment and Human Factors, Germany; e-mail: grosjean.mc@googlemail.com)

Research on shifts of visuospatial attention in perihand space have apparently lead to conflicting findings. In particular, whereas some Posner cueing studies have found that hand proximity modulates the size of cueing effects, others have not. One reason for such discrepancies may be related to the types of cues (uninformative and informative) that have been used, as they are known to induce different types of shifts of attention (involuntary and voluntary, respectively). To systematically address this question, two experiments were performed in which an uninformative peripheral cue (experiment 1) or an informative central cue (experiment 2) preceded a peripheral target with a short (100–150 ms) stimulus-onset asynchrony. Participants performed the tasks under four hand positions: Left hand, right hand, both hands, or no hands near the display. Cueing effects were obtained in both experiments, however, in contrast to experiment 2, experiment 1 also revealed an interaction between cue validity and hand position. This reflected that there was a larger cueing effect in the right- and both-hands conditions than in the other conditions. These findings suggest that involuntary shifts of attention are affected by hand proximity, while voluntary shifts are not.

◆ **Top-down control in contour grouping: an EEG study**

³ G Volberg¹, A Wutz², M W Greenlee¹ (¹University of Regensburg, Germany; ²University of Trento, Italy; e-mail: gregor.volberg@psychologie.uni-regensburg.de)

Human observers tend to group oriented line segments into full contours following the Gestalt rule of ‘good continuation’. It is commonly assumed that contour grouping emerges automatically in early visual cortex. In contrast, recent work in animal models suggests that contour grouping requires learning and thus involves top-down control from higher brain structures. Here we explore mechanisms of top-down control in perceptual grouping by investigating synchronicity within EEG oscillations. Human participants saw two micro-Gabor arrays in a random order, with the task to indicate whether the first (S1) or the second stimulus (S2) contained a contour of collinearly aligned elements. Contour compared to non-contour S1 produced a larger posterior post-stimulus beta power (15–21 Hz). Contour S2 was associated with a pre-stimulus decrease in posterior alpha power (11–12 Hz) and in fronto-posterior theta (4–5 Hz) phase couplings, but not with a post-stimulus increase in beta power. The results indicate that subjects used prior knowledge from S1 processing for S2 contour grouping. Expanding previous work on theta oscillations, we propose that long-range theta synchrony shapes neural responses to perceptual groupings by either up- or down-regulating lateral inhibition in early visual cortex.

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◆ **Core characteristics defining the nature of unilateral neglect syndrome**

- 4 M Pavlovskaya¹, N Soroker¹, Y Bonne², S Hochstein³ (¹Loewenstein Rehabilitation Hospital, Tel Aviv University, Israel; ²Dept of Neurobiology, Brain Research, Weizmann Institute of Science, Rehovot, Israel; ³Life Sciences Institute, Hebrew University, Jerusalem; Israel; e-mail: marinap@netvision.net.il)

We are studying perceptual-cognitive capabilities of patients with unilateral neglect. Traditionally, neglect is the inability to perceive left-side stimuli, not due to lack of sensation. Deficits may include failure at cancellation and line-bisection tasks and extinction. Results from our study series put strong constraints on underlying mechanisms of Neglect. We determine neglect/extinction rigorously measuring left-side Gabor-patch contrast threshold in presence/absence of right-stimuli. Left-side perception is statistical, with accurate contrast determination for perceived stimuli. Thus, contrast sensitivity reduction is not low-level attenuation, but reflects heightened-threshold at higher processing levels, preventing conscious awareness of sensory events. We find great differences between the impacts of neglect on tasks requiring focused attention (conjunction search) versus those requiring spread attention (feature search), suggesting neglect only affects the process of focusing attention, and that spread-attention deficits only arise from extinction-like effects. Similar results derive from experiments on patients' assessing statistical properties of clouds of elements. USN patients compute full-field means, giving reduced weight to left-side stimuli, largely due to extinction. This confirms the conclusion that neglect is a high-level effect, which prevents conscious integration of left-side elements with those on the right, especially in cases where stimulus elements are present on both sides. [This research was supported by the Israel Science Foundation (ISF) and the US-Israel Bi-national Science Foundation (BSF), as well as the National Institute for Psychobiology in Israel (NIPI) to author MP.]

◆ **Attentional preference for attractive faces**

- 5 N Kloth¹, L Short², G Rhodes¹ (¹ARC Centre of Excellence in Cognition and its Disorders, School of Psychology, The University of Western Australia, Australia; ²Brock University, Canada; e-mail: nadine.kloth@uwa.edu.au)

Faces are stimuli of outstanding social relevance, and our visual system seems to dedicate "special" mechanisms and separate neural resources to their processing. In line with this, faces also receive privileged attentional resources when presented amongst non-face objects, possibly from a separate face-specific attentional system with a capacity limit of one face at a time. It is therefore plausible to assume that some faces stand out more than others when presented within a group. Prior research indeed has shown that faces displaying certain emotional expressions or direct gaze are preferentially attended. However, the effect of other facial characteristics on attentional selection has hardly been explored. Here, we used a modified dot-probe paradigm to investigate the existence and nature of attentional preferences for highly attractive faces relative to less attractive faces. We found some evidence of an attentional bias towards attractive faces. Factors such as SOA, participant gender, and stimulus gender modulated this effect, suggesting that facial attractiveness biases attention in a complex manner, interacting with other characteristics of both the stimulus and the observer.

◆ **Development of visual working memory and its relation to academic performances in elementary school children**

- 6 H Tsubomi, K Watanabe (The University of Tokyo, Japan; e-mail: htsubomi@fennel.rcast.u-tokyo.ac.jp)

Visual working memory (VWM) enables active maintenance of visual information. It is also crucial to exclude distractors in order to keep once-stored items in VWM. Here, we investigated how VWM would develop and become distractor-proof in Japanese elementary school children and their relations to academic performances in the classroom. A total of 123 Japanese children (7- to 12-year-old) were instructed to remember the positions of 4 colored squares for a 2-sec retention period filled with blank or visual distractors. In the blank retention condition, the VWM capacity reached the average adult level (ie, three objects) at 10-year-old. However, the VWM capacity in the visual distractor condition did not reach the adult level until 12-year-old. Children with high VWM capacity in the visual distractor condition tended to exhibit higher academic performances (Japanese language, arithmetic, science, and social studies) than those with low VWM capacity. These results suggest that the capacity of VWM matures earlier than the exclusion process of visual distractors for VWM and they might have relations to academic achievement in elementary school children.

◆ **Does oculomotor preparation have a functional role in social attention?**

7 D Smith, E Morgan (Durham University, UK; e-mail: daniel.smith2@durham.ac.uk)

Observing a change in gaze direction triggers a reflexive shift of attention and appears to engage the eye-movement system. However, the functional relationship between social attention and the oculomotor activation is unclear. One extremely influential hypothesis is that the preparation of an eye movement is necessary and sufficient for a shift of attention (the Premotor theory of attention; Rizzolatti et al, 1987 *Neuropsychologia* **25** 31–40). In order to test this hypothesis for social attention we examined gaze-cueing under conditions where the preparation of some eye-movements was not possible. Contrary to the Premotor theory, we observed significant and robust gaze cueing at locations to which observers could not prepare an eye-movement. However, although gaze-cueing was unaffected by eye-abduction overall participants were much poorer at detecting changes that occurred in the temporal hemifield when the eye was abducted. This finding is consistent with previous reports that changes in posture can elicit attentional biases. These data demonstrate that motor preparation is functionally dissociated from social attention and may be problematic for theories of social cognition that propose a link between the ability to make inferences about the intentions of others and the ability to activate the corresponding motor plan in their own action system.

◆ **Preventing oculomotor preparation disrupts spatial but not visual or verbal working memory**

8 K Ball¹, D Pearson², D Smith¹ (¹Durham University, UK; ²University of Aberdeen, UK; e-mail: k.l.ball@durham.ac.uk)

We used the eye abduction paradigm (Craigheero, Nascimben and Fadiga, 2004 *Current Biology* **14** 331–333) to separate the contributions of covert attention and oculomotor processes on working memory. Stimuli were presented wholly in the nasal or temporal hemifield, and the participant's dominant eye was either in the centre of its orbit (frontal condition) or abducted by 40° as a result turning their head and body while maintaining central fixation (abducted condition). Spatial memory was assessed using either the corsi blocks task or arrow span, and visual memory was assessed using the visual patterns task or a size estimation task. Verbal memory was measured using digit span. We found a significant interaction between field of presentation and eye position in the corsi block task, with eye abduction reducing spatial memory span for temporally presented stimuli. This effect was not seen in the arrow span task, or for visual and verbal memory. As abduction makes it physically impossible to both execute and plan eye-movements to locations further into the temporal hemifield, we conclude that the oculomotor system is involved in visuospatial working memory for specified locations but not when directional information indirectly cues these locations.

◆ **The use of motion information in multiple object tracking**

9 M Huff, F Papenmeier (University of Tübingen, Germany; e-mail: markus.huff@uni-tuebingen.de)

In multiple-object tracking participants track several moving target objects among identical distractor objects. Recently it was shown, that the human visual system uses motion information for keeping track of targets. A texture on an object that moved in the opposite direction than the object impaired tracking performance. In this study, we examined the temporal interval at which motion information is integrated in dynamic scenes. In three multiple-object tracking experiments, we manipulated the texture motion on the objects: The texture moved either in the same direction, in the opposite direction, or alternated between same and opposite direction at varying interval lengths. We show that motion integration can take as short as 100 ms. Further, we show that there is a linear relationship between the proportion of opposite motion and tracking performance. That is, increasing the proportion of opposite motion within the alternate conditions decreased tracking performance. We suggest that texture motion might cause shifts in perceived object locations thus influencing tracking performance.

◆ **Texture segregation and contour integration depend on right-hemisphere attention-related brain areas**

10 K Vancleef¹, J Wagemans¹, G Humphreys² (¹University of Leuven [KU Leuven], Belgium; ²University of Birmingham, University of Oxford, UK; e-mail: kathleen.vancleef@ppw.kuleuven.be)

Whether perceptual organization requires attention is still uncertain. Extinction patients who have problems in attending to a contralesional stimulus when two competing stimuli are presented, provide us with the opportunity to study the role of attention-related brain areas in the presence of intact low-level visual areas. Although we know that a wide range of perceptual grouping processes are unimpaired

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in these patients, texture segregation and contour integration are unexplored. In this study, four right and five left extinction patients, as well as twelve healthy controls, were presented with texture and contour stimuli consisting of oriented elements. We induced regularity in the stimuli by manipulating the element orientations resulting in an implicit texture border or explicit contour. Subjects had to discriminate curved from straight shapes without making eye movements while stimulus presentation time was varied according to a QUEST procedure. Results show that for both textures and contours, only the left extinction patients need a longer presentation time to determine the shape of the border/contour on the contralesional side. These results indicate that texture segregation and contour integration are modulated by attention-related brain areas in the right hemisphere, such as the right temporo-parietal junction (TPJ), which is typically damaged in extinction.

◆ **Configural effects on positional priming of pop-out**

11 A Gökce, T Geyer (Ludwig Maximilians Universität, Turkey; e-mail: ahu.goekce@psy.lmu.de)

This study investigated facilitatory and inhibitory positional priming using a variant of Maljkovic and Nakayama's priming of pop-out task (Maljkovic and Nakayama, 1996 *Perception & Psychophysics* **58**(7), 977–991). In three experiments, the singleton target and the distractors could appear within variable (illusory) configurations (triangle, square, etc.) across trials. This manipulation was intended to disentangle the relative contributions of configural (ie, a leftward-pointing triangle followed by a rightward-pointing triangle display) and categorical (ie, a diamond followed by a leftward pointing triangle display) information on positional priming. The results were that of significant facilitatory and inhibitory priming effects. However, while facilitation was contingent on configural information, inhibition was reliant on repetition of item categories across trials. These results suggest that facilitatory and inhibitory priming are distinct phenomena (Finke et al, 2009 *Psychological Research* **73**, 177–185) and that positional memory traces include subtle information about the arrangement of the items.

◆ **Interactions between top-down colour and bottom-up luminance signals during sustained visual attention**

12 J Martinovic¹, J Mordal¹, S K Andersen² (¹School of Psychology, University of Aberdeen, UK; ²Dept of Neurosciences, University of California San Diego, USA; e-mail: j.martinovic@abdn.ac.uk)

We examined the interplay between bottom-up luminance contrast and top-down colour-selection biases in sustained visual attention. This EEG experiment consisted of an S – (L + M) block, with bluish and yellowish dots, and an L-M block, with reddish and greenish dots. Two fully overlapping, flickering random dot kinematograms (RDKs) were presented, with the dots being either at the same or at different luminance levels, both brighter than the background. On each trial, participants were colour-cued to attend one RDK in order to detect brief coherent motion targets, whilst ignoring any events in the unattended RDK. Performance was lowest for bluish. Reaction time differences between colours were observed at low target luminance levels only, with bluish being the slowest. Furthermore, steady-state visual evoked potential (SSVEP) amplitude for bluish did not depend on target luminance levels, while for the other colours amplitude was higher at low levels of target luminance, following a similar pattern as reaction time differences. We conclude that feature-selection is equally effective for concurrent luminance and L-M inputs and S-cone decrements, with S-cone increments being selected less effectively. The neural basis of observed colour-luminance interactions is likely to reside at least partly in earlier visual areas that receive low-level chromatic inputs.

◆ **Previously fixated visual features improve scene recognition**

13 C Valuch, U Ansorge (University of Vienna, Faculty of Psychology, Dept of Psychological Basic Research, Austria; e-mail: ulrich.ansorge@univie.ac.at)

During examination of a scene, only a limited amount of visual features is fixated. How do such fixations help in recognizing familiar scenes? In our eye tracking study, participants first viewed a series of natural scenes on photographs. Contingent upon the individual fixation pattern of every participant, two classes of smaller cutouts were extracted from each of the viewed photographs. The fixated/old cutout showed the region of longest fixation, and the control/old cutout showed a region that was not fixated but contained salient low-level feature contrasts. Subsequently, participants saw three types of trials (randomly intermixed): (1) Trials with fixated/old cutouts, (2) trials with control/old cutouts, and (3) trials with new cutouts (the latter from new, hitherto not presented photographs). All cutouts were shown at screen center. The task was to rapidly and accurately decide whether a cutout was from an old or a new photograph. With fixated/old cutouts reaction times were significantly lower than with control/old

cutouts and new cutouts. Moreover, recognition accuracy was at chance level for control/old cutouts and above chance in all other conditions. Our results point to the significance of reorienting attention and gaze to previously fixated visual features during the successful recognition of natural scenes.

◆ **Is inhibition of return reset by a subsequent search in the same display?**

- 14 M Höfler¹, I D Gilchrist², C Körner¹ (¹University of Graz, Austria; ²University of Bristol, UK; e-mail: mhoefer@iicm.edu)

Inhibition of return (IOR) discourages the re-inspection of recently inspected items. When a search is finished and immediately followed by a subsequent search in the same display, IOR is reset at the end of the previous search (Höfler et al, 2011 *Attention, Perception, and Psychophysics* **73**(5), 1385–1397). However, other researchers have demonstrated that IOR is still functioning after a single search has finished (eg Klein, 1988 *Nature* **344**, 430–430). Here we investigated whether it is the start of the subsequent search that resets IOR once the previous search has finished. To this end, participants had to search consecutively twice in the same display while their eye movements were monitored. Immediately after the end of the first and after the end of the second search we probed one of the items. The probed item had been previously inspected or not. Saccadic latencies to the probes were used to measure IOR. Again, IOR was reset at the end of the previous search. However, we also found IOR to be reset after the end of the subsequent search (ie, when no further search followed). This suggests that the start of a subsequent search is not responsible for the resetting of IOR.

◆ **Electrophysiological correlates of multiple object processing in the absence of awareness**

- 15 S Pagano¹, V Mazza² (¹Center for Mind/Brain Sciences, University of Trento, Italy; ²Center for Mind/Brain Sciences, Dept of Cognitive Sciences and Education, University of Trento, Italy; e-mail: silvia.pagano@gmail.com)

Representing multiple objects simultaneously is fundamental to interact efficiently with the environment. Such ability requires at least two mechanisms. A first attentional mechanism individuates a limited amount of elements and produces coarse object representations by attaching features to indexed locations. A second working memory (WM)-related mechanism encodes objects in greater detail leading to full object representation. This electrophysiological study investigated whether these two stages underlying multiple objects processing require awareness to operate. We asked participants to enumerate a variable number of targets (0–3) presented among distractors while recording two neural markers—the N2pc and CDA—likely associated with individuation and WM, respectively. On target-present trials, one target was surrounded by a four-dot configuration that offset together with the stimulus (common-offset) or not (delayed-offset). Participants' accuracy was lower on delayed-offset trials, indicating the occurrence of a reliable masking effect. ERP results showed that the amplitude of N2pc increased as a function of target numerosity both in delayed- and common-offset trials, whereas such modulation was present for CDA only on common-offset trials. The results indicate that while individuation can operate with reduced awareness, WM-related processes cannot, and suggest that awareness is progressively required to build a complete representation of multiple objects.

◆ **Pointing to the temporal modulation of attentional effects on face categorisation**

- 16 G Quek, M Finkbeiner (ARC Centre of Excellence for Cognition and its Disorders, Dept of Cognitive Science, Macquarie University, Australia; e-mail: genevieve.quek@mq.edu.au)

A range of experimental paradigms and clinical case studies have now demonstrated the unique resilience of faces to attentional modulation. The present study sought to examine the effect of tightly controlled spatial and temporal attention on the processing of masked face stimuli. Using a sensitive continuous measure, reaching trajectories, we have shown that masked faces produce priming irrespective of how well attention is focussed in space or time. Nevertheless, by examining reaching responses as a function of target viewing time, we have demonstrated for the first time that the timecourse of masked priming is subject to modulation by both spatial and temporal attention. When attention is optimally focussed, subjects need to view the target for a shorter length of time to produce reliable priming

◆ **Distractor processing in serial visual search: Evidence from fixation-related potentials**

- 17 C Körner¹, V Braunstein¹, M Stangl¹, A Schlögl², C Neuper¹, A Ischebeck¹ (¹Universität Graz, Austria; ²Institute for Science and Technology, Austria; e-mail: christof.koerner@uni-graz.at)

The search for a target in a complex environment is an everyday visual behavior that stops on finding the target. When we search for two identical targets, however, we have to continue the search after finding the first target and memorize its location. We had participants perform a multiple-target search

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and measured eye movements and EEG simultaneously. We used fixation-related potentials (FRPs) to investigate the neural correlates of different stages of the search. Having found the first target influenced subsequent distractor processing. Compared to distractor fixations before the first target fixation, a negative shift was observed for three subsequent distractor fixations. This result suggests that processing a target in continued search modulates the brain's response, either transiently by reflecting temporary working memory processes or permanently by reflecting working memory retention.

◆ **Fruitful search: Top-down contingent capture extends to colour-variegated stimuli**

18 N Heise, U Ansorge (Universität Wien, Austria; e-mail: nils.heise@univie.ac.at)

In the past, highly-controlled visual search paradigms used monochromatic stimuli to confirm top-down contingent capture of attention by colour (eg Folk and Remington, 1998). These studies lack one critical aspect of everyday colour search: colour variegation. This could be crucial because colour-variegated targets cover a larger colour spectrum and thus exhibit potentially more overlap with irrelevant colour distractors. In addition, top-down search settings for colour-variegated stimuli could be more demanding. As a consequence, top-down contingent capture could be restricted to artificial monochromatic stimuli. To study colour capture under more natural conditions, we used photographs of real fruits/vegetables as colour-variegated stimuli. In experiment 1, we nonetheless found evidence for top-down contingent capture of attention by colour-variegated stimuli. These results could have partly reflected response interference. This was ruled out in experiment 2. Together, results demonstrated that top-down contingent capture extends to colour-variegated stimuli.

◆ **Strategic scanning in visual search: Implications for the measurement of attentional bias**

19 J Hobson, S Butler (University of Strathclyde, UK; e-mail: stephen.butler@strath.ac.uk)

Several theories of addiction posit that drug-related stimuli, through processes of classical conditioning, are able to elicit physiological and subjective craving (for review see Franken, 2003, *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 27 563–579). Attentional bias to drug-related stimuli is argued to be a key mechanism in this process, however, our understanding of its role and mechanisms remain unclear, possibly due to task limitations. The present study measured eye movements whilst participants completed a flicker change blindness task employing three conditions of grid like displays, which differed in degree of structural regularity, with both an alcohol and neutral change competing for detection. The results demonstrated no significant difference in behavioural or eye movement measures of attention to alcohol related stimuli between non-drinkers, light drinkers and heavy social drinkers, suggesting that social drinkers do not display an alcohol related attentional bias. However, there was evidence of strategic scanning in all conditions, demonstrated by the frequency of saccade directions. The extent of which was modulated by the level of regularity of the grids structure. Therefore the ability of the flicker change blindness task to accurately measure attentional bias may be limited, highlighting important implications for future attentional bias research.

◆ **Emotional inconsistencies capture attention irrespective of valance**

20 I Amihai, F Chua, S Yen (National University of Singapore, Singapore; e-mail: idoamihai@gmail.com)

Previous studies have shown that objects that are inconsistent with the semantic gist or physical structure of a scene lead to longer fixation durations (Vo and Henderson, 2009 *Journal of Vision* 9 1–15). Stimuli with negative emotions have also been shown to capture attention faster than positive or neutral stimuli (Yang, Zald, and Blake, 2007 *Emotion* 7 882–886). In the current study we investigated both semantic and structural scene inconsistencies in the context of emotion. We performed eye tracking experiments in which subjects were presented with natural images that contained a face that was inconsistent with the emotional gist of the scene or with its physical structure. We found that emotionally and structurally inconsistent faces were viewed for a longer period of time relative to consistent faces, with mean differences of 797 ± 109 ms (two-sample *t*-test, $p < 0.001$) and 938 ± 161 ms ($p < 0.001$) for the emotional and structural conditions, respectively. Moreover, the emotional valence of the face did not influence this effect, and positive and negative inconsistent faces were equally fixated ($2,522.5 \pm 164$ ms vs $2,522.9 \pm 179$ ms, $p > 0.99$). [Acknowledgment: A*Star Human Factors Engineering Thematic Strategic Research Program.]

◆ **Colour as a cue of sexual attractiveness and attentional preference in Japanese Macaques**

- 21 L S Pflüger¹, C Valuch², U Ansorge², B Wallner¹ (¹Cognitive Science Research Platform, Dept of Anthropology, Faculty of Life Sciences, University of Vienna, Austria; ²Cognitive Science Research Platform, Dept of Psychological Basic Research, Faculty of Psychology, University of Vienna, Austria; e-mail: lena.pflueger@univie.ac.at)

Japanese Macaques and humans possess highly comparable colour vision which could serve similar functions, eg the interpretation of socio-sexual signals in hairless skin colouration. We investigated the significance of facial reddishness as a cue to sexual attractiveness and attentional preferences in semi free-ranging Japanese macaques during their reproductive period. We presented two pictures of the same female face on two monitors to different male monkeys individually ($n = 22$). The presented faces were carefully manipulated in a natural range of reddish facial colours. We analyzed male behaviour (gaze duration/frequency, and number of approaches towards one versus the other monitor) as a function of the presented stimuli. Male behaviour differed between individuals but in a subset of the sample increased attentional behaviour towards faces with higher shades of facial red was clearly observable. We further incorporated the social dominance ranks as well as endocrinological data into our analyses to clarify the degree to which these variables moderate attention towards the socio-sexual stimuli. Our results add to the knowledge about the adaptive functions of colour vision and are of relevance for research on colour perception in humans and non-human primates.

◆ **Cognitive mechanisms underlying attentional blink and creative reasoning**

- 22 S Jaarsveld, P Srivastava, M Welter, T Lachmann (University of Kaiserslautern, Germany; e-mail: priyanka.divya@gmail.com)

Attentional blink (AB) magnitude depends on the individual differences in working memory operation span (OSPAN) over and above the effects of fluid intelligence. Fluid intelligence, measured with Standard or Advanced Progressive Matrices (SPM/APM) is shown to be positively correlated with creative reasoning defined as the ability to shift between 'divergent and convergent production'. In the Creative Reasoning task participants create a puzzle in a 3x3 matrix, similar to Raven's matrices. It is assumed that performance on both AB and CRT tasks, although evolving in different time scales, might be based on a general cognitive flexibility. Two experiments were conducted (N1 = 50, with SPM; N2 = 50, with APM) employing the AB task, OSPAN, test of creative thinking (TSD), and creative reasoning task (CRT). Results showed no significant correlation ($p > 0.05$) between AB and creative reasoning, suggesting possibly distinct cognitive mechanisms underlying these two processes. Specifically, based on the current results, it can be speculated that AB involves more narrow attention, whereas CRT involves relatively broader attention. Follow-up experiments are currently being conducted to identify the specific cognitive mechanisms underlying AB and creative reasoning.

◆ **Visual search in barn owls: orientation pop-out?**

- 23 J Orłowski, T Stemmler, H Wagner (RWTH Aachen University, Germany; e-mail: Julius@bio2.rwth-aachen.de)

Investigations of the mechanisms underlying visual attention have a long history in human and primate research. We detect a differently oriented object amongst a set of distracters independent of the number of distracters. This is called pop-out. We were interested whether other vertebrates have similar capabilities and chose the barn owl as a role model, because in this bird gaze can be tracked with a head-mounted camera, the OwlCam. We designed two experiments: In one, barn owls were confronted with patterns on the floor of a room containing one odd target amongst several identical distracters. The gaze path and fixations were examined. In this setting the barn owls looked faster, more often and longer at the object than at a randomly chosen distracter. This experiment demonstrated visual search capabilities, but it does not allow determining reaction time. In the second approach we currently train barn owls to observe two patterns displayed at different locations on a monitor. The time the owl will need to press a switch that signifies the location of the target will be measured. If this time were independent of the number of distracters, pop-out existed in barn owls.

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◆ **Attentional gain control and competitive interactions influence visual stimulus processing independently**

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C Keitel¹, S K Andersen², C Quigley³, M M Müller¹ (¹Universität Leipzig, Germany; ²University of California at San Diego, USA; ³German Primate Center, Germany; e-mail: keitel@rz.uni-leipzig.de)

We tested two assumptions of a biased competition account of human visual attention: (1) An attended stimulus is released from a mutually suppressive competition with concurrently presented stimuli and (2) an attended stimulus experiences greater gain in the presence of competing stimuli than when it is presented alone. To this end, we recorded frequency-tagged potentials elicited in early visual cortex that index stimulus-specific processing. We contrasted the processing of a given stimulus when its location was attended or unattended and in presence or absence of a nearby competing stimulus. At variance with previous findings, competition similarly suppressed processing of attended and unattended stimuli. Moreover, the magnitude of attentional gain was comparable in the presence or the absence of competing stimuli. We conclude that visuospatial selective attention does not per se modulate mutual suppression between stimuli but instead acts as a signal gain, which biases processing toward attended stimuli independent of competition.

◆ **Optimizing attention deployment in object-based attention: the role of cue validity**

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W Chou¹, S Yeh² (¹Dept of Psychology, Fo-Guang University, Taiwan, Taiwan; ²Dept of Psychology, National Taiwan University, Taipei, Taiwan, Taiwan; e-mail: chouweilun@ntu.edu.tw)

Using the classic Egly, Driver and Rafal (1994) two-rectangle paradigm, we examined the effect of cue validity on object-based and location-based attention. We manipulated the likelihood of a target appearing on the same object versus the different object, in the invalid cue conditions: informative of location but not object (experiment 1), informative of location and object (experiment 2), and informative of object but not location (experiment 3). The results indicated a spatial-cueing effect (ie, shorter RT at the cued location than at the uncued location) and a same-object advantage (ie, shorter RT for the cued object than for the uncued object) when the location-based and object-based cues were informative, respectively (experiments 1 and 3), and both spatial-cueing effect and same-object advantage when both kinds of cues were informative (experiment 2). Unlike previous studies in which the two kinds of cues were co-varied, this study differentiates the two, and the results obtained are inconsistent with either the spreading hypothesis or the prioritization hypothesis of object-based attention. As explained by our optimization hypothesis, we demonstrate here that the validity of the location cue is not the causal reason for the same-object advantage; object-based cue validity-the probability that the target will appear on the cued object as a whole-plays a decisive role in object-based attention.

◆ **N2pc attentional capture by threatening schematic faces**

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N Burra, D Kerzel (Université de Genève, Switzerland; e-mail: nicolas.burra@unige.ch)

It has been reported that attention detects highly relevant stimuli in an automatic manner. In recent studies measuring event-related potentials, it has been demonstrated that fearful faces capture attention. However, other studies demonstrate that threatening, angry faces can also facilitate the allocation attention. Moreover, behavioral interference effects have been observed when these facial expressions are task-irrelevant. We suggest that expression-related interference can be measured electrophysiologically by using the N2pc which is an index of the attentional selection of lateralized stimuli. We displayed a variant of the "additional singleton" paradigm in which the main task was not related to facial expressions and the irrelevant distracters were angry or happy faces. Our data demonstrate that independently of the task, facial expression stimuli increased the face-related N170 component as compared to neutral faces and, mainly, that only irrelevant angry faces elicit an N2pc while happy faces do not. Different perspectives and control experiments are discussed.

◆ **Predicting visual perception: an ERP approach**

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H Pincham, D Szucs (Cambridge University, UK; e-mail: hlp31@cam.ac.uk)

Neuroscientific explanations of successful visual perception typically focus on the neural events elicited by stimuli. However, there is evidence to suggest that the ongoing state of the brain can predict whether or not a visual stimulus will be perceived. Here, we used the attentional blink paradigm in combination with event-related brain potentials to examine whether neural activity before a stimulus can determine successful stimulus detection. Participants were required to detect 2 target letters from digit distractors while their brain activity was being recorded. Trials were classified based on whether the second critical target (T2) was detected. We found that T2-detection was predetermined by brain activity prior to

the onset of the stimulation stream. Specifically, T2-detected trials were predicated by a frontocentral positive going deflection that started more than 200 ms before the stream began. Accurate T2 detection was also accompanied by enhanced poststimulus neural activity, as reflected by a larger P3b component. Furthermore, prestimulus and poststimulus markers of T2-detection were highly correlated with one another. The results suggest that conscious visual perception is shaped by potentially random fluctuations in neural activity.

◆ **How old are you? The effect of face age on gaze-following behaviour**

28 F Ciardo, A Rossetti, R Actis-Grosso, P Ricciardelli (Dept of Psychology, University of Milano-Bicocca, Italy; e-mail: francesca.ciardo@yahoo.it)

Gaze following is considered a building block of social interaction. Several studies have shown that the interaction between two people is influenced by similarity (ie, perceived overlap between two individuals). Age is known to be an important similarity factor (Preston and de Wall, 2002 *Behavioral and Brain Sciences* 25 1–20). Using an oculomotor task, we tested whether the degree of perceived similarity, as indicated by the age of the other person's, can modulate gaze following. Distracting faces of four different age ranges (8–10; 18–25; 35–45 and over 70 years old) gazing left or right were presented to university students. Their task was to ignore the distractor while making a saccade towards one of two horizontal peripheral targets, depending on the color of an instruction cue. The distracting gaze could be congruent or incongruent with the instructed direction. The results show that participants made more errors in incongruent than in congruent trials ($p = 0.014$). Interestingly, gaze following errors (errors in the direction of the distracting gaze in incongruent trials) increased when the distractor's age (18–25 years old) matched the age of participants, indicating that similarity in terms of membership of a perceived age group can modulate gaze following behaviour

◆ **Task-dependent crossmodal processing of combined visuo-auditory conjunction oddballs in a mixed sequence of visual and auditory stimuli**

29 E B N Friedel, M Bach, S P Heinrich (University of Freiburg, Germany; e-mail: evelyn.friedel@gmx.net)

Can attention be captured by oddball stimuli that are defined through the conjunction of visual and auditory features and embedded in a random sequence of non-conjunct stimuli? We used the P300 of the event-related potential as an index for the allocation of attention. Four different conditions were tested. (1) Rare conjunction stimuli embedded in sequence of non-conjunct auditory and visual stimuli, with auditory stimuli (conjunct or not) attended. (2) Same stimulus sequence as before, but conjunction stimuli attended. (3) Rare auditory stimuli (non-conjunct) in sequence of visual stimuli (non-conjunct), with auditory stimuli attended. (4) Rare visual stimuli (non-conjunct) in sequence of auditory stimuli (non-conjunct), with auditory stimuli attended. In both non-conjunction sequences, the rare stimuli elicited similar P300 responses, despite the visual stimuli not being attended. No P300 was found with conjunction stimuli when auditory stimuli were attended. With the conjunction stimuli being attended, a P300 was present, but small and delayed, compared to non-conjunction conditions. The results suggest that visuo-auditory conjunctions are not processed preattentively, and even when task-relevant they require additional processing that delays and disperse the allocation of attention. As the non-conjunction sequences show, this is not due to the fact that the visual modality is disattended.

◆ **Performance related visual attention and awareness of social evaluative cues in social anxiety**

30 M Mckendrick, M Grealy, S Butler (University of Strathclyde, UK; e-mail: mel.mckendrick@strath.ac.uk)

Schultz and Heimberg (2008 *Clinical Psychology Review* 28(7) 1206–1221) reviewed cognitive biases in social anxiety, concluding that without direct measures in ecologically valid paradigms, limited knowledge of attentional focus could be ascertained. In response, we tracked eye-movements during a social performance task. Participants were told that a 'live web linked interview panel' was evaluating their performance. Despite no differences in visual attention early in the task, both trait anxiety and unexpected situational anxiety in more confident individuals appeared to have increased awareness of social cues. As the task progressed, more visual attention was paid to emotional than neutral social cues. The low anxiety group were aware of more negative cues, whereas the high anxious group were equally aware of all behaviours. Afterwards, high anxious participants rated private and public evaluation more negatively than low anxious individuals. Thus situational anxiety in the early performance stages may disrupt preferential allocation of attention to emotional faces but heighten awareness of social cues.

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However as attention to emotional faces increases, less socially anxious individuals may be better able to discriminate a genuine emotional threat than those with high social anxiety.

◆ **Just passing through: lack of IOR in planned saccade sequences**

31 W J MacInnes, H Krueger, A Hunt (University of Aberdeen, UK; e-mail: j.macinnes@abdn.ac.uk)
Responses tend to be slower to previously attended spatial locations. This is known as Inhibition of Return (IOR). We compared IOR for intermediate locations along planned and unplanned saccade sequences. Sequences of two saccades were instructed using a colour-based verbal cue. In the planned condition all the saccade target colours were visible before the saccade sequence began. In the unplanned condition, the second colour did not reveal itself until after the first saccade was initiated. Following the sequence a probe was presented at the first saccade target location or a control location. With saccadic responses to probes, IOR was observed only when saccade sequences were unplanned. IOR was absent for planned saccade sequences. IOR was also predominantly observed when probes appeared soon after the saccade sequence, and was absent later. When we repeated the experiment with manual responses to probes, IOR was absent in both planned and unplanned sequences. The results show that intermediate locations along a pre-planned sequence are not inhibited. When the sequence cannot be planned in advance, intermediate locations are inhibited, but this inhibition appears to be transient and stronger for saccadic responses, suggesting a motor rather than attentional locus.

◆ **Qualitative differences between attention capture by conscious and unconscious cues**

32 I Fuchs¹, J Theeuwes², U Ansorge¹ (¹University of Vienna, Austria; ²Vrije Universiteit Amsterdam, Netherlands; e-mail: isabella.fuchs@univie.ac.at)
Classical attention theory assumes exogenous capture of attention by unconscious cues and endogenous capture by conscious cues. Here we tested the classical view by varying cue visibility. In experiment 1, we demonstrate that unpredictable cues (equally likely at target position and away from the target) lead to capture. With conscious cues, attention capture was restricted to endogenously fitting cues: If the participants searched for black targets, black but not white cues captured attention, and this pattern reversed if white targets were searched for. By contrast, with unconscious cues, capture was equal for searched and unsearched contrast-cues. In experiment 2, we used antipredictive cues: After 75% of the right cues, the target was on the left and after 75% of the left cues the target was on the right. Here, participants endogenously directed attention towards the opposite side of the conscious but not of the unconscious cue. Together, the findings support the classical view.

◆ **Visual word recognition in latvian children with and without reading difficulties**

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In Latvia approx. 15–20% of school-aged children are with reading difficulties. Latvian is complicate language and cause of poor reading has not been studied. There are many neural processes which participate in text decoding during reading. The aim of the study was to determine differences in visual word recognition for children with and without reading difficulties. Fifty-two children from Grade 3 ($n=22$) and Grade 4 ($n=30$) took part in the study. Using a modified One minute reading test, children were divided in two groups—with and without reading difficulties. The stimulus set for word recognition contained 150 words. The length of the words varied from four to ten letters. Each word was shown on a computer screen for 500 ms. The answers were expected verbally. Correct and incorrect answers were recorded. Each word length was shown 15 times. Letter size corresponded to 6 cycles/ degree. Data of correctly named words for children with and without reading difficulties were significantly different ($p<0.05$) in both groups for all word lengths. The study confirms that children with reduced reading speed use letter-by letter reading pattern, when normal reading children use parallel letters activation. Word recognition and processing speed improves with age and lexical experience.

◆ **Averaging of simultaneous instances of familiar and unfamiliar faces**

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There is growing evidence that faces are represented in terms of a summary description based on shared features of multiple, previously seen faces. This phenomenon has been reported for multiple faces that have been processed either sequentially (eg Burton, Jenkins, Hancock, and White, 2005 *Cognitive Psychology* **51** 256–284) or simultaneously (eg De Fockert, and Wolfenstein, 2009 *Quarterly Journal of*

Experimental Psychology **62**(9) 1716–1722). Here we investigate the relationship between sequential and simultaneous averaging, by measuring averaging of simultaneously presented faces that either have (familiar faces) or have not (unfamiliar faces) also received sequential processing prior to the experiment. Participants were asked to match a single test face with one of a set of four previously seen photographs of the same person. A morphed average of all four set members and a previously seen photograph were equally likely to be endorsed as having been present in the previous set. Interestingly, a morphed average of four previously unseen photographs was endorsed significantly more often than a single previously unseen photograph. This effect was the same regardless of the familiarity of the face to the observer.

◆ **The time course of cueing: When is it U-shaped and when not?**

35 A Wilschut, J Theeuwes, C N L Olivers (VU University Amsterdam, Netherlands;
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Performance in spatial cueing tasks is often characterized by a rapid attentional enhancement with increasing cue-target SOA. A recent study (Wilschut et al, 2011 *PLoS ONE* **6** e27661) found that this enhancement function also applies when the cue and the target are presented invariably at a single central location, suggesting a universal cueing time course. However, using a very similar central task, others have found a rather different, U-shaped pattern, reminiscent of an attentional blink (Nieuwenstein et al, 2009 *Journal of Vision* **9** 1–14). The present study varied the properties of the cue-target pair in order to investigate the mechanisms underlying the different time functions. In several experiments, accuracy was generally found to improve with the increasing cue-target SOA. The level of performance at the shortest cue-target intervals (33–83 ms), however, depended on the relative strength of the cue and the target, akin to what has been found in visual masking studies. We suggest that the early part of the attentional cueing function is modified by stimulus-based visual interactions, and that these together with later attentional effects determine whether the cueing time course is U-shaped or monotonic.

◆ **The effects of cross-sensory attentional demand on subitizing and on mapping number onto space**

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Various aspects of numerosity judgments, especially subitizing and the mapping of number onto space, depend strongly on attentional resources. We use a dual-task paradigm to investigate the effects of cross-sensory attentional demands on visual subitizing and spatial mapping. The results show that subitizing is strongly dependent on attentional resources, far more so than is estimation of higher numerosities. But unlike many other sensory tasks, visual subitizing is equally affected by concurrent attentionally demanding auditory and tactile tasks as it is by visual tasks, suggesting that subitizing may be amodal. Mapping number onto space was also strongly affected by attention, but only when the dual-task was in the visual modality. The non-linearities in numberline mapping under attentional load are well explained by a Bayesian model of central tendency.

◆ **On the perception of natural scenes: proto-objects versus spatial locations**

37 V Yanulevskaya, J Uijlings, N Sebe (Dept of Information Engineering and Computer Science, University of Trento, Italy; e-mail: yanulevskaya@disi.unitn.it)

Do people attend to spatial locations or to discrete objects while looking around? Most of state-of-the-art models for visual attention are based on the spatial-based attention theory. This states that every time we move our eyes, information from a circular region around the gaze is being processed, where the shape of this region is supposed to be fixed. Alternatively, the object-based attention theory argues that people perceive the world as a collection of proto-objects, which are coherent image regions that, by visual coherence in most objects in the world, roughly correspond to part of an object, complete object, or group of objects. Within this theory, the shape of the attended region is influenced by the visual structures of the image and coincides with proto-objects. We propose a visual attention model based on object-based attention theory, where we automatically extract proto-objects using hierarchical image segmentation. We compare our object-based model with a state-of-the-art spatial-based attentional model on the task of eye-fixation prediction. Our results demonstrate that by distributing saliency within proto-objects, we efficiently highlight entire image regions, which attract most of the attention. In contrast, the spatial-based method generally highlights only high contrast details, which mostly coincide with object borders.

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◆ **A study to evaluate peripheral visual perception**

38 I Timrote, G Krumina, T Pladere, M Skribe (Dept of Optometry and Vision Science, University of Latvia, Latvia; e-mail: Gunta.Krumina@lu.lv)

There are disorders linked to M, P visual pathways that can be improved until certain age (Parrish et al, 2005 *Vision Research* **45** 827–837). For this reason we are developing a method to evaluate peripheral visual perception. An individual has to count a specific letter from a set of letters on white background, in lines or in squares in central visual field and no noise, five times five or ten times ten black dots in peripheral visual field. Additional peripheral stimulus in different size appears during the task. Time needed to accomplish the counting is statistically significant for two of the individuals ($p < 0.05$)—it takes more time to count letters in white central background comparing with letters in squares or in lines. A black stimulus should be in size of 4 cm and green, red or blue stimulus in size of 2 cm for a figure to be distinguished in the peripheral visual field. Three individuals did not notice any of the peripheral stimuli. Therefore our method can be used to evaluate peripheral perception hence trying to look for a problem in visual pathways, although we have to make some improvements to adapt these tests for children.

◆ **The effects of temporal cueing on metacontrast masking**

39 S Mota, M Bruchmann (Institute for Biomagnetism and Biosignalanalysis, Germany; e-mail: Maximilian.Bruchmann@uni-muenster.de)

Temporal information can induce expectations about when a given event will occur; expectations that facilitate perception by selectively directing attentional resources to discrete moments in time (temporal orienting effect). A temporal analog to the standard spatial cueing paradigm was used to examine the effects of temporal attention on the perception of briefly presented visual stimuli in a metacontrast masking paradigm. Subjects rated the visibility of a target stimulus that was followed by a mask after various stimulus onset asynchronies. In two separate runs subjects were made to expect the target either after 100ms or 1s. In some instances, however, the subjects' expectations were violated by presenting the target earlier or later than assumed. We observed cueing effects in the form of higher visibility when the target appeared at the expected point in time compared to when it appeared too early. Unlike spatial cueing effects on metacontrast masking reported in the literature, these effects were not restricted to the late branch of the masking function, but enhanced visibility over its complete range. These results suggest that the neural subsystems involved in temporal attention differ from those involved in spatial attention.

◆ **Neural activity in category-selective regions is modulated by both subjective and physical disappearance**

40 A Loing, R van Lier, A Koning, F de Lange (Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behavior, Netherlands; e-mail: floris.delange@donders.ru.nl)

Although it is well-known that early visual areas can contain stimulus representations in the absence of subjective awareness, it is more controversial whether high-level visual areas such as the fusiform face area (FFA) and parahippocampal place area (PPA) are driven by physical stimulus properties or subjective perception. We examined whether physical and/or subjective disappearance of face and house stimuli modulated the neural activity in FFA and PPA, using a contrast decrement technique. Nine participants participated in an fMRI experiment. On each trial, the participants were shown a face or house stimulus, after which the stimulus was either removed (physical disappearance) or its contrast was reduced, leading to subjective disappearance of the stimulus in a proportion of trials (on average, 53%). Category-selective neural activity in FFA and PPA was lower during physical disappearance, in the context of equal subjective experience. It was also lower during subjective disappearance, in the context of equal physical stimulation. Together, these results demonstrate that neural activity in category-selective higher-order visual regions is not solely determined by the subjective experience of perceiving the category, but rather represents sensory evidence for its category, on the basis of both physical stimulus characteristics and subjective experience.

◆ **Eye movement behaviour to natural scenes as a function of sex and personality**

41 F Mercer Moss, R Baddeley, N Canagarajah (University of Bristol, UK; e-mail: f.mercermoss@bristol.ac.uk)

Women and men are different. As humans are highly visual animals, these differences should be reflected in the pattern of eye movements they make when interacting with the world. We examined fixation distributions of 52 women and men while viewing 80 natural images and found systematic differences

in their spatial and temporal characteristics. The most striking of these was that, compared to men, women looked away and usually below many objects of interest, particularly when primed with the task for threat. We also found reliable gaze differences correlated with the images' semantic content, the observers' personality, and how the images were semantically evaluated. Information theoretic techniques showed that many of these differences increased with viewing time. The effects reported are not small: the fixations while viewing a still from a single action or romance film, on average, allow the classification of the sex of an observer with 64% accuracy. Our results indicate that while men and women may live in the same environment, what they see in this environment is reliably different. Our findings have important implications for both past and future eye movement research while confirming the significant role individual differences play in visual attention.

◆ **Do all negative images similarly retain attention? Time course of attentional disengagement from disgust- and fear-evoking stimuli**

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While disgust and fear are both negative emotions, they are characterized by different physiology and action tendencies, which might in turn lead to different attentional biases. However, the potential disgusting aspect of threatening stimuli has somehow been neglected which might contribute to discrepancies in the literature. The goal of this study was to examine whether fear- and disgust-evoking images produce different attentional disengagement patterns. We pre-selected IAPS images according to their disgusting, frightening, or neutral character and presented them as central cues while participants had to identify a target letter briefly appearing around them. To investigate the time course of disengagement from those central images, we used 4 different cue-target intervals (200, 500, 800 and 1100 ms). Reaction times were significantly longer with the disgust-evoking images than with neutral- and fear-evoking images at the 200 ms interval only. This suggests that only disgust- and not fear-related images hold participants' attention for longer. This might be related to the need to perform a more comprehensive risk-assessment of disgust-evoking pictures. These results have important implications for future emotion-attention research as they indicate that a more careful selection of stimulus materials that goes beyond the dimensions of valence and arousal is needed.

◆ **Letter crowding and the benefit of parafoveal preview during reading**

43 S Risse (University of Potsdam, Germany; e-mail: sarah.risse@uni-potsdam.de)

Adjacent letters in peripheral vision induce crowding that prevents efficient letter recognition. The region of effective vision (ie, where crowding does not compromise letter identification) can be described by means of visual-span profiles (VSPs). VSP parameters have shown to predict reading rate suggesting that crowding limits processing beyond central vision and slows down reading. We investigated crowding as an effect influencing parafoveal preview benefit during normal reading. Eye movements were recorded of 58 subjects while reading single-line sentences in which preview of a word was denied until the eyes crossed an invisible boundary to the left of the word. Fixation durations revealed substantial benefit when preview was available, but the size of such preview benefit did not correlate with subjects' VSPs. Based on estimation of individual VSP accuracies on trial level, linear mixed-model analyses confirmed that letter-identification performance at the preview location modulated fixation durations but did not interact with preview condition. Thus, crowding seems to affect processes different from those involved in parafoveal preview benefit, potentially on the level of visual word encoding. The accumulation of preview information for subsequent word recognition seems to be less affected supporting the importance of cognitive processing on eye guidance during normal reading.

◆ **Local object gist by symmetries of lines and edges in V1**

44 J Pinilla-Dutoit, D Lobato, K Terzic, J Du Buf (Vision Laboratory, LARSyS, University of the Algarve, Portugal; e-mail: dubuf@ualg.pt)

Global gist vision addresses entire scenes. The purpose of local gist is to prepare a spatial layout map before precise object recognition is achieved: which types of objects are about where in a scene. In case of man-made objects, often a repertoire of geometric shapes like rectangles and ellipses can be applied (Martins et al, 2009 *Perception* **36** ECVF Supplement, 41–42). In case of less geometric shapes, other object properties must be employed. We are therefore developing a model for extracting symmetries. This model exploits the multi-scale line and edge representation in area V1 (Rodrigues and du Buf, 2009 *BioSystems* **95** 206–226). It is a V2 model because larger line and edge fragments and angles are

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represented there. Sets of grouping cells are used to detect symmetric pairs of lines and edges with different angles. When applied at different scales, the combined results yield a sort of tree structure or skeleton, although not in the sense of the medial axis transform. This structure describes an object's main shape with links to corners at the object's contour. Once trained to individual objects viewed against a homogeneous background, the model can be applied to spot the objects in complex scenes. [Projects: PEst-OE/EEI/LA0009/2011, NeFP7-ICT-2009-6 PN: 270247.]

◆ **Spatial attention does not influence object substitution masking**

- 45 M Pilling, A Gellatly, I Argyropoulos (Oxford Brookes University, UK;
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The distribution of spatial attention is deemed to be a critical variable in Object Substitution Masking (OSM: a phenomenon in which a brief target is rendered imperceptible by surrounding mask elements which trail target offset). For instance DiLollo and colleagues (DiLollo, Enns, and Rensink, 2000 *Journal of Experimental Psychology: General* **129** 481–507) report that OSM is dramatically reduced when attention was spatially prior-cued to the target location (by presenting the mask elements before onset of the stimulus array). We review this and other claims which argue for a role of attention in OSM and present alternative accounts of the results. We further present three experiments in which we manipulate spatial attention using a cueing paradigm. All experiments find that valid pre-cueing of the target location increases the perceptibility of a target stimulus, however in none of the experiments is there an interaction with mask duration. We conclude on the basis of these and other results from our laboratory that spatial attention is not a relevant factor in OSM. We discuss the implications of this for understanding of OSM itself, and for theories of re-entrant processing and object-updating.

◆ **Implicit social learning in relation to autistic-like traits**

- 46 T Jellema¹, T Nijboer², M Hudson³ (¹Hull University, UK; ²Universiteit Utrecht, Netherlands;
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We investigated if the extent in which typically-developed individuals possessed autistic-like traits (using the Autism-spectrum Quotient, AQ) influenced their ability to implicitly learn the social dispositions of others. In the learning phase of the experiment, participants repeatedly observed two different identities who displayed specific combinations of gaze direction and facial expression, such that they conveyed either a pro- or antisocial disposition toward the observer. Debriefing indicated that participants were not aware that they had learned something about these identities. The second phase of the experiment consisted of a gaze-cueing paradigm, in which the gaze directions of the two identities (displaying neutral expressions) were used to cue the appearance of peripheral targets. Participants made speeded responses to target appearance; gaze directions were non-predictive of target location. The low AQ group ($n = 50$) discriminated between the two identities: they showed a smaller gaze-cueing effect for the antisocial than for the prosocial identity. In contrast, the high AQ group ($n = 48$) showed equivalent gaze-cueing effects for both identities. The results first of all suggest that others' intentions/dispositions can be learned implicitly. Second, they suggest that this ability becomes impaired with increasing levels of autistic-like traits.

◆ **Spatio-temporal dynamics of visual processing in autism revealed by attentional masking**

- 47 L Ronconi¹, S Gori¹, E Giora², M Ruffino³, A Facoetti¹ (¹Dept of General Psychology, University of Padova, Italy; ²Dept of Psychology, University of Milano-Bicocca, Italy; ³Unità di Neuropsicologia dello Sviluppo, Istituto Scientifico E. Medea di Bosisio Parini, Lecco, Italy;
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Autism spectrum disorder (ASD) has been associated with a detail oriented perception and an overselective attention. However, both clinical observations and experimental studies highlighted an inefficient visual selection under certain conditions. In order to understand this dissociation, we investigated the spatio-temporal dynamics of visual processing in children with ASD and IQ-matched typically developing (TD) controls, employing an Attentional Masking paradigm. Attentional Masking refers to a reduction in target identification that is followed by a second irrelevant masking object at different degrees of proximity in space and time. We found that the performance of ASD and TD group did not differ when the masking object was displayed in the same position of the target. In contrast, when the masking object appeared in lateral position in respect to the target, children with ASD showed a deeper and prolonged interference on the target identification compared to the TD group. These findings contribute to explain the dissociation between over- versus under-selectivity of visual processing in

ASD, and could be interpreted in the light of the altered neural connectivity hypothesis and the reentrant theory of perception.

◆ **Introspection during visual search**

48 G Reyes¹, J Sackur² (¹Laboratoire de Sciences Cognitives et Psycholinguistique CNRS/EHESS/IEC—ENS, France; ²Laboratoire de Sciences Cognitives et Psycholinguistique CNRS/EHESS/IEC—ENS and Institut Universitaire de France, France; e-mail: gureyes@puc.cl)

Recent advances in the field of metacognition have shown that participants are introspectively aware of many different cognitive states, such as their confidence in a decision, their feeling of knowing the answer to a memory question, or their own internal decision time. Here we set out to expand the range of introspective knowledge put under experimental scrutiny by asking whether participants could introspectively differentiate between two types of visual searches. We designed a series of experiments where we contrasted easy, feature searches, where the target of search is expected to pop-out, and difficult, conjunction searches, requesting more serial processing. In addition to traditional first order performance measures, we instructed participants to give, on a trial-by-trial basis, an estimate of the number of elements perceived before a perceptual decision was reached. Results show partial awareness of the processing difference: participants seemed unable to give a numerical estimate of pre-decision perceived elements, while they could qualitatively distinguish pop-out from effortful searches. Our results are consistent with the two-stage models for visual search: we show that depending on task context and instructions, participants gave more weight in their introspections either on the first, pre-attentive stage, or on the second, guided search stage. In general, this introspective distinction was overshadowed by the more salient introspective decision time. Implications for models of visual search are drawn.

◆ **The existence of purely serial search shows that visual search is actually parallel**

49 J Hulleman (University of Manchester, UK; e-mail: johan.hulleman@manchester.ac.uk)

In purely visual search, items are processed one at a time. On target present trials, search terminates when the target is found. On target absent trials, all items have to be inspected. Variability in reaction times should be larger on present trials, since all items are equally likely to be the target. Participants searched for T amongst L (medium) and for a square with a smaller square in the left top corner amongst squares with a smaller square in another corner (difficult). For medium search, reaction time variability was smaller for present trials. However, for difficult search reaction time variability was larger for present trials. Moreover, there was also more variability in the number of fixations on present trials. The serial nature of difficult search implies that easier search is not serial. Recently, Young and Hulleman (*JEP:HPP* in press) have proposed a theoretical framework that predicts these results. Visual search is modeled as a combination of serial fixations and parallel processing within fixations. The number of items processed within a fixation depends on task difficulty. When search becomes very difficult, the number of items processed is reduced to one and only the serial component due to eye movements is left.

◆ **Attention orienting shifts the numerical distance effect**

50 M Ranzini, M Lisi, M Zorzi (University of Padova, Italy; e-mail: mari.ranzini@gmail.com)

The tendency to represent small numbers on the left and large numbers on the right of “mental number space” has been reported by many studies. Visuo-spatial attention is thought to mediate number-space interactions, but a detailed investigation of how attention orienting may modulate number processing is lacking. We investigated this issue by manipulating the voluntary deployment of visuo-spatial attention during a number comparison task. Each trial started with a visual cue displayed at one of four spatial locations (horizontally placed, two at each side of fixation). Then, a target digit (1–9, without 5) was centrally presented and participants orally indicated whether it was larger or smaller than the reference 5. Finally, they were prompted to make a saccade to the cued position. Comparison reaction times were influenced by the position of the spatial cue. In addition to a correspondence effect between cue position and number magnitude, we found that the numerical distance effect—slower responses for targets close to the reference than far ones—was modulated by the spatial cue, as if the reference 5 was “mentally shifted” in the direction of the cued position. This finding indicates that attention mechanisms play an important role in number processing.

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◆ **Does contextual cueing occur in a comparative search task?**

- 51 M P Aivar (Facultad de Psicología, Universidad Autónoma de Madrid, Spain;
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Ever since the classic experiments performed by Chun and Jiang (Chun and Jiang, 1998 *Cognitive Psychology* 36 28–71) it is known that the repetition of spatial context reduces RTs in visual search tasks when the context is predictive of target location. However one of the biggest problems of the traditional contextual cueing paradigms is that they require a massive number of trials for the effects to appear. Also, it is not clear how far cueing effects can be generalized to other tasks. In this study we try to reproduce contextual cuing in a different task (comparative search) and with a smaller number of trials (120). In each trial, the screen was divided into two halves and a random configuration of elements was presented in each. Both halves could either be identical or differ on one element's color. Five configurations were repeated 12 times along the experiment, intermixed with newly generated configurations. Participants had to determine whether the two halves of the screen were identical or not. Results showed that RTs were significantly shorter for the repeated configurations, but only on those trials in which both halves were identical. This suggests a partial contextual cueing effect. [Research supported by grant FFI2009-13416-C02-02.]

◆ **The process of impression formation for faces in a gaze cueing task**

- 52 H Ogawa¹, M Nunoi², S Yoshikawa³ (¹Dept of Integrated Psychological Sciences, Kwansei Gakuin University, Japan; ²Graduate School of Education, Kyoto University, Japan; ³Kokoro Research Center, Kyoto University, Japan; e-mail: hirokazu.ogawa@kwansei.ac.jp)

In a gaze cueing task, faces whose gaze directions are always predictive of a target location are evaluated as more trustworthy than those whose are not (Bayliss and Tipper, 2006 *Psychological Science* 17(6) 514–520). In the present study, we examined how the impressions on the predictive faces are developed over time. In a gaze cueing task, participants were presented some faces that always looked at the target (valid faces) and the other faces that always looked at the opposite side of target (invalid faces). Each face was presented either from one to 12 times in the cueing trials. The results showed that the amounts of the gaze cueing effect was consistent across the number of presentations. Furthermore, the participants evaluated the valid faces as more trustworthy than the invalid faces, which is consistent with the previous studies. However, this bias decreased as the number of presentations increased. A recognition task confirmed that the participants were not aware of the relationship between the validity of gaze directions and face identities. The discrepancy between the cueing effect and the evaluation of the faces suggests that the impressions of the faces were modulated independently of the attentional guidance by gaze directions.

◆ **Visuomotor adaptation to prismatic lenses influences numerical cognition**

- 53 M Yates¹, C Vicario², T Loetscher³, M Nicholls³ (¹University of Melbourne, Australia; ²SISSA (La Scuola Internazionale Superiore di Studi Avanzati), Italy; ³Flinders University, Australia; e-mail: mjyates@unimelb.edu.au)

Representations of visual space and number appear to be linked. Neglect patients -who demonstrate a pathological bias to the right side of space—misjudge the midpoint between two numbers—eg “11” and “19”—to the ‘right’ of the true midpoint—eg “17”. Conversely, healthy individuals display a (smaller) bias to the left matched by a tendency to mis-bisect numerical intervals leftwards. One interpretation of these phenomena is that shifts of attention in external space elicit corresponding shifts of attention within mental representations. However, the evidence that shifts in spatial attention can alter numerical cognition rests largely on number line bisection data. To determine whether these effects extend to other tasks, we investigated the effect of spatial attention on random number generation. Thirty-six participants generated 40 random numbers (from 1–30) before and after adaptation to either: left-shifting optical prisms, right-shifting prisms or control spectacles. Against expectations, participants who adapted to left-shifting prisms (eliciting a rightward shift of attention) generated smaller numbers after adaptation versus before adaptation. By contrast, there was no difference between the magnitude of numbers generated before versus after adaptation to right-shifting prisms or control spectacles. Possible explanations for these results are considered.

◆ **Asymmetries in saccadic latencies during interrupted ocular pursuit**

54 H Bieg¹, J Bresciani², H H Bülthoff¹, L L Chuang¹ (¹Max Planck Institute for Biological Cybernetics, Germany; ²Laboratoire de Psychologie et Neurocognition, CNRS, UMR 5105, Université Pierre Mendès, France; e-mail: bieg@tuebingen.mpg.de)

Smooth pursuit eye movements can be interrupted and resumed at a later stage, eg, when a concurrent task requires visual sampling from elsewhere. Here we address whether and how interruptive saccades are affected by pursuit movements. Our participants pursued an object which moved horizontally in a sinusoidal pattern (frequency: 0.25 Hz, amplitude: 4 deg. visual angle). During this, discrimination targets appeared at 10 deg. eccentricity, to the left or right of the center. They were timed so that they appeared for 1 second while the pursuit object moved either toward or away from the discrimination target's position. Saccade reaction times were earlier when the discrimination targets appeared in a position that the tracking object was moving towards. Interestingly, saccade RTs back to the pursuit object were shorter when the object moved away from the discrimination target. We conclude that interruptions of pursuit movements lead to asymmetries in saccade generation. These asymmetries could have been caused by biases in attention along the predicted pursuit path.

◆ **Motion-related allocation of attention doesn't depend on a set towards a moving object**

55 N Tiurina, I Utochkin (National Research University Higher School of Economics, Russian Federation; e-mail: natalyatyurina@gmail.com)

We probed attentional allocation over space caused by motion perception with two attentional sets towards a moving object. Observers had to respond rapidly to a briefly presented probe asterisk while seeing a straightforwardly moving circle. A probe could be presented either beside, behind, or in front of a moving circle as well in the absence of a circle. The first group of observers was instructed to ignore a moving circle as potentially disrupting probe detection. The second group was instructed to track a circle. We expected, according to a hypothesis by Utochkin (Utochkin, 2009 *Attention, Perception & Psychophysics* **71** 1825–1830), that tracking a moving object aids allocation of attention in front of motion while ignoring doesn't. Our results essentially replicated those reported by Utochkin. We found faster responses to all probes in the presence than in the absence of a moving circle. 'Behind' condition yielded additional benefit in reaction time in comparison with 'beside' and 'in front' conditions suggesting involuntary allocation of attention to locations previously marked by motion. Contrary to our hypothesis, the pattern was the same for both ignoring and tracking groups but tracking RTs were systematically slower reflecting cost of dividing attention between tracking and probe detection.

◆ **Attentional modulation of configurational preference for visual hierarchical stimuli by an insect brain**

56 A Avargues-Weber¹, A G Dyer², M Giurfa³ (¹Queen Mary, University of London, UK; ²Monash University, Australia; ³CRCA-UMR 5169-CNRS-Université Toulouse III, France; e-mail: a.avargues-weber@qmul.ac.uk)

How do visual systems construct meaningful representations of complex natural scenes? Do the brains first analyse the details of a scene (featural information) to reconstruct the complexity, or do they first analyse the scene as a whole (global configurational construct) to then process the details? We used hierarchical stimuli to investigate global/local preferences in honeybees. The bee is a classical model to assess the mechanisms underlying learning and visual perception. Indeed the bees learning capacity associated with its relatively simple brain enables novel insights into biological mechanisms that may be applied to artificial visual systems. The bee has also to learn to use its vision to recognize complex spatial information in noisy natural environments for efficient foraging and navigation behavior. We show that honeybee demonstrates an initial preference for global processing independent of stimulus density. This result is surprising in the context of traditional models of insect processing, but is consistent with new evidence of configural type processing in bees. Importantly we reveal that the bee brain also possesses the neural flexibility to modulate preferences to either local- or global-features depending upon specific contexts like image priming. The bee's preference to process configurations is thus not hardwired due to physiological or evolutive constraints but can be modulated by experience.

◆ **Attentional bias and spider fear: a prior entry-study**

57 A Haberkamp, M Schröder, T Schmidt (University of Kaiserslautern, Germany; e-mail: haberkamp@sowi.uni-kl.de)

It is widely accepted that spider phobics show an early attentional bias towards spiders. Beyond, attended stimuli are perceived as occurring earlier compared to unattended stimuli. The latter effect of prior entry

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“is usually identified by a shift in the point of subjective simultaneity (PSS) in temporal order judgments (TOJs)” (Weiß and Scharlau, 2011 *Quarterly Journal of Experimental Psychology* **64**(2), 394–416). We wondered if the attentional bias of spider phobics is strong enough to trigger a prior entry impression. In our study with spider-fearful and non-anxious participants, we presented natural images of animals (spiders, snakes, and butterfly) in pairs with neutral natural images (flowers, and mushrooms) on both sides of the fixation cross with a varied time interval between the onset of the two stimuli (SOA: 0ms, 12ms, 24ms, 35ms, 47ms). Our participants had to judge which picture appeared first and indicate the position of the image (left or right). As a result, spider pictures induced a significant difference between the two groups. Spider-fearful participants perceived the spider pictures relative to the neutral images as occurring earlier. Neither snakes nor butterflies led to a prior entry impression.

◆ **Role of landmark objects in the orienting of attention across saccades**

58 M Lisi¹, P Cavanagh², M Zorzi¹ (¹University of Padova, Italy; ²University Paris Descartes, France; e-mail: matteo_lisi@yahoo.it)

Covert attention can facilitate visual processing at selected relevant locations, but what happens if the eyes move elsewhere? Recent studies have shown that attentional facilitation lingers at the retinotopic coordinates of the previously attended position after an eye movements (Golomb, Chun and Mazer, 2008 *Journal of Neuroscience* **28** 10654–62). These results are puzzling, since the retinotopic location is behaviourally irrelevant in most ecological situations and also raise the question of how we can accomplish tasks that require both frequent eye movements and dissociations between gaze and attentional focus (eg, team sports). Critically in these studies participants were asked to maintain attention on a blank location of the screen, not on a defined object. In this study we tested whether the continuing presence of a visual object at the cued location influences the postsaccadic attentional topography. We used a trans-saccadic cueing paradigm in which the relevant positions could be defined or not by squared black frames. Results show that the presence of the squares selectively increases the attentional facilitation at the spatiotopic location compared to the retinotopic after the saccade. Overall, the spatiotopic cueing effects predominate over retinotopic when the cued object remains present following the saccade.

◆ **Does an object's contrast affect attention and detection equally?**

59 B M 'T Hart¹, H Schmidt¹, I Klein-Harmeyer¹, C Roth², W Einhäuser¹ (¹Neurophysics, Philipps University Marburg, Germany; ²Neurology, Philipps University Marburg, Germany; e-mail: wet@physik.uni-marburg.de)

When images are presented in quick succession (rapid-serial-visual-presentation, RSVP), low-level features, like luminance contrast affect object detection. Since objects attract attention, such features may affect detection and gaze (overt attention) similarly. To test this, we used identical stimuli in two tasks; prolonged viewing and RSVP. Stimuli consisted of natural images, in which the luminance contrast of an object and its background were independently manipulated. In prolonged viewing, eye positions were recorded during 3s of presentation. Subsequently, observers provided keywords describing the scene. In RSVP, observers' performance in detecting a target object in a 1-second stream of 20 images was tested. Although gaze control and detection performance are very different measures, changes in the low-level feature (luminance-contrast) affect both alike. Further experiments reveal that the pattern of results does not depend on the presence of distractor objects, and that the changes in luminance contrast do not change how characteristic an object is perceived to be for the scene. These results imply that scene content interacts with low-level features to guide both detection and overt attention (gaze), while certain aspects of higher-level scene perception are not affected by the same low-level features.

◆ **The time course of attention allocation in textures of different homogeneity**

60 T Feldmann-Wüstefeld, A Schubö (University of Marburg, Germany; e-mail: tobias.fw@uni-marburg.de)

Searching a target in a texture does not only depend on target but also on texture properties, presumably due to differential attention allocation (Duncan and Humphreys, 1989). Aim of the present study was to reveal the time course of attention deployment within textures of varying degrees of homogeneity. To that end a search task was combined with a probe detection task. Probes could appear at the same or at a different location as previously presented targets. The screen onset asynchrony (SOA) between texture and probe was varied to track attention allocation at different points in time. Behavioral measures and event-related potentials (ERPs) showed that homogeneous textures lead to more efficient attention allocation than heterogeneous contexts, causing fewer erroneous answers, shorter N2pc latencies and

larger N2pc amplitudes. Probes appearing at target locations yielded shorter RTs and larger P1 amplitudes for all SOAs, indicating a persistent sensory gain due to attention shifts. This on-target advantage was more pronounced in trials with homogeneous contexts for short SOAs, but disappeared at longer SOAs, suggesting that the impact of texture homogeneity outlasts the texture presentation for some time but vanishes thereafter.

◆ **Female capture of other females faces**

61 S Butler, T Tafili (University of Strathclyde, UK; e-mail: stephen.butler@strath.ac.uk)

The human face, due to its high social and biological significance captures and retains our attention; hence it is also better remembered when compared to other objects. Female faces are only better remembered by females, resulting in an Own-Gender Bias (having a better memory for faces of their own gender). Males however do not show such a bias. The mechanisms underlying Own-Gender Bias have not been fully understood. The present study examines whether there are differences in attentional capture and retention between male and female faces, and whether these differences are more prominent in males or females. A measure of reaction time and eye movement behaviour was taken during a visual search task where the face was not task relevant. Results indicate that while there is no influence on latencies, an initial orientation effect is present for females. The presence of a female face slowed down the females' attention towards the search target; however the male face did not have such effect. This initial orientation does not seem to last, indicating that females' attention tends to be only captured initially by the female face, and not held by it.

◆ **Visual search for a feature-singleton: Not all display densities are made equal**

62 D Rangelov, H J Müller, M Zehetleitner (Ludwig-Maximilians-Universität München, Germany; e-mail: rangelov@psy.lmu.de)

In visual search tasks, a feature-singleton target, eg, red among green distractors, can be found on the basis of two different properties: (i) it is a unique item, and (ii) it has a particular feature. The former is known as the singleton search mode, and the latter as the feature-search mode. Previous research showed profound differences between the singleton- and feature-search, suggesting different cognitive mechanisms underlying the two modes. Presently, we investigated whether or not different display densities influence the search mode. The target was either red or green singleton, randomized across trials. Across two consecutive trials the target could either change or repeat: reaction times are typically faster for repetitions relative to changes, an effect termed Priming-of-Popout (PoP). As recent accounts relate PoP to the feature-search mode, its non/existence in an experiment indicates whether singleton- or feature-search mode was used. Comparing PoP magnitude for sparse (3) and dense (36 items) showed a dissociation between densities: PoP was significant only for sparse displays. These findings suggest that, although the singleton-search mode was possible in all conditions, sparse displays do not allow for valid target selection based solely on its uniqueness. Contrary to accounts of feature-singleton search, simply having singleton targets does not suffice for singleton-search mode to operate efficiently.

◆ **Visual symptoms in children and adults with autism spectrum disorder**

63 D Simmons, A Robertson (University of Glasgow, UK; e-mail: David.Simmons@glasgow.ac.uk)

Autism Spectrum Disorders (ASDs) are common developmental disorders thought to affect at least 1% of individuals. Official diagnostic criteria for ASD concentrate on signs and symptoms associated with social behaviour, but sensory difficulties are also a major component in its presentation (Simmons et al, 2009 *Vision Research* 49 2705). We have investigated sensory aspects of ASD using questionnaires and focus groups. This work is necessary as a precursor to better-targeted behavioural experiments. Focus groups were conducted with children ($n=10$) and adults with ASD ($n=6$). The visual symptoms reported were consistent with severe visual stress: sensitivity to bright light, flicker from fluorescent lamps and repetitive patterns like shelving or grids, sometimes reported as being painful. A subset also reported idiosyncratic responses to certain colours. Whilst positive sensory responses were also reported, most of these were not (obviously) in the visual domain, but seemed to be mainly tactile. A major factor in whether or not sensory stimulation is problematic appears to be the amount of control the individual has over its amplitude, rather than the amplitude itself, potentially suggesting a major role for attentional factors. These results will be put into the context of current neural models and intervention strategies for ASD.

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◆ **Differential phase-encoded method revealed location of spatial attention-related activities in parietal, temporal and occipital cortex: an fNIRS study**

64 M Harasawa¹, M Nambu², M Kitazaki², H Ishikane³ (¹Japan Broadcasting Corporation, Japan; ²Toyohashi University of Technology, Japan; ³Senshu University, Japan; e-mail: harasawa.m-ii@nhk.or.jp)

Variation of location of visuospatial attention causes modulation of neural activities. Here, we demonstrate this effect could occur in a variety of cortical areas including parietal, temporal and occipital cortex by functional near-infrared spectroscopy and the technique using continuously modulated visual stimuli and differential neural responses (Tajima et al, 2010 *JNS* **30**(9), 3264–3270; Saygin and Sereno, 2008 *Cerebral Cortex* **18**(9), 2158–2168). Subjects performed RSVP task detecting numbers among alphabets arranged circularly and peripherally. The target position continuously moved clockwise along the circle at the speed of 360 deg / min. The initial position of the target was the top or the bottom of the circle and was cued before the task period lasting 75 sec. The changes of oxy-Hb concentration were measured at 47 points covering parts of parietal, temporal and occipital cortex. Differential responses by the initial target position were fitted by sinusoid with the wavelength of 60 sec. The fitted phases were almost opposite for left and right cerebral hemispheres. This result was reproduced even with different moving speed, direction, and frame rate, and disappeared in the control condition with center RSVP task. These results suggest even the cortical areas apparently without retinotopy are involved in location-specific spatial attention.

◆ **Direction information acquired from attended objects not from distractors in MOT**

65 J Lukavsky (Academy of Sciences of the Czech Republic, Czech Republic; e-mail: lukavsky@praha.psu.cas.cz)

In the current experiment we tested to what extent we process the motion information from the tracked objects. Specifically, we were interested, whether Multiple Object Tracking (MOT) display can affect sensitivity to motion, which is in the direction of either targets or distractors. In the first experiment we presented two random dot motion displays (RDM) in quick sequence (coherence 0% or 30%). The subjects were asked to detect whether coherent motion was present in the later display. We manipulated the angular difference of RDM's and found higher accuracy for 0deg or 180deg differences. In the second experiment we presented MOT task with 3 targets and 6 distractors, followed with RDM for 500 ms. The subjects were asked about the targets and the direction in RDM. We confined direction of the tracked object, at each moment only 3 directions were allowed, making sum of motion vectors constant. We measured the threshold for coherence in RDM for conditions: (1) motion parallel with recent motion of the targets, (2) motion different from the motion of the targets, (3) different motion of the targets. We found decreased sensitivity in the second condition, suggesting that we preferentially process the direction information from the attended objects.

◆ **How do we use the past to predict the future in oculomotor search?**

66 B Vincent (University of Dundee, UK; e-mail: b.t.vincent@dundee.ac.uk)

A variety of findings indicate that visual search can become more efficient by using various featural, spatial, and temporal cues in the world that are probabilistically related to a search target. More specifically, the results of two experiments are reported that examine how we make predictions about the location of a target in an upcoming search based upon previous experience. Previously, it was known that search can adapt to situations in which simple statistics govern target location, such as a spatial bias, but it was unclear what mechanism was responsible for this and to what extent search adapts to different kinds of environmental statistics. Participants conducted a simple gaze-contingent oculomotor search task for a target in 1 of 4 locations under 5 conditions, each with different 1st or 2nd order statistics govern the target's location. In general, participants rapidly adapted their search to the prevailing statistics. A mechanistic model proposed by others to account for priming in pop-out search tasks could only account for search behaviour when the environmental statistics were simple, and was not able to provide a robust account of how observers searched in all conditions. However, a very simple probabilistic model that makes predictions based upon past observations provided a good account of how the participants searched across all 5 conditions. The results constrain possible models of search, and suggest that while people bring assumptions to search tasks, people can quickly adapt to the statistics of the environment.

◆ **Does inhibition of return during joint action reflect individual attentional processes?**

- 67 M A Atkinson¹, G G Cole¹, A Simpson¹, P A Skarratt² (¹University of Essex, UK; ²University of Hull, UK; e-mail: mark.andrew.atkinson@googlemail.com)

When two individuals act alternately upon visual targets in three-dimensional environments, an individual is frequently slower to respond to a target following a response by another individual to the same target (Welsh et al, 2005 *Neuroscience Letters* **385** 99–104). It has been suggested that this social inhibition of return (SIOR) effect is due to simulating the motor processes of another individual, such that individuals are relatively slower to execute an action after observing the same action in another. It is possible however, that response slowing is due to an egocentric inhibition of return (IOR) mechanism where attention is slow to return to recently attended locations. The aim of the present work was to examine whether this IOR-like effect is a consequence of attentional orienting. Two experiments demonstrate that like IOR, SIOR is modulated by the perceptual grouping of targets and the requirement to discriminate, rather than detect targets. In addition, the magnitude of an individual's SIOR effect is correlated with their performance on a two-dimensional IOR task, where no goal-directed actions are made. These findings support that hypothesis that SIOR is due to egocentric shifts of visual attention.

◆ **Spatial representation of time in music**

- 68 V Prpic¹, A Fumarola², M De Tommaso², I Gratton², T Agostini² (¹University of Trieste, Dept of Life Science, Italy; ²University of Trieste, Dept of Life Science, Italy; e-mail: valter.prpic@phd.units.it)

The Spatial Numerical Association of Response Codes (SNARC) suggests the existence of an association between number magnitude and response position, with faster left-hand responses to small numbers and faster right-hand responses to large numbers (Dehaene et al, 1993 *Journal of Experimental Psychology: General* **122** 371–396). Moreover, Rusconi et al (2006 *Cognition* **99** 113–129) showed that the internal representation of pitch height is spatially organised, especially in participants with formal musical education (ie, Spatial Musical Association of Response Codes: the SMARC effect). We investigated whether a similar association exists between time in music (beats per minutes) and the spatial position of response execution. The first task were to judge the timbre of beat sequences (metronome vs non-metronome) pressing the right/left key with the right/left hand. The second task were to judge whether a beat sequences was faster or slower than a reference sequence. Results showed a global trend with faster left-hand responses to “slow” beats and faster right-hand responses to “fast” beats. We can conclude that the musical tempo is spatially represented as pitch height and the number.

◆ **Can bees see at a glance?**

- 69 V Nityananda, P Skorupski, L Chittka (Queen Mary University of London, UK; e-mail: v.nityananda@qmul.ac.uk)

Both humans and monkeys are capable of extremely rapid scene categorization, making visual decisions about scenes in under 100 ms. Is this capacity to represent and process scenes in a sensory snapshot a consequence of the bigger brain size and computational power of primates? If so, one would predict that other animals, such as insects, that have far smaller brains, would be incapable of such rapid decisions and have to actively scan the scene instead. No studies have, however, investigated whether non-primates have the capability to see at a glance or not. We used a learning paradigm to ask if bumblebees could learn to detect and discriminate between stimuli which were presented for durations of 100 ms or less. We find that bumblebees can detect the presence of stimuli and discriminate between differently oriented stimuli even when they are presented as briefly as 20 ms. This is the first demonstration of a non-primate seeing at a glance and our results raise questions of how bumblebees can process visual features this rapidly and whether they are capable of seeing more complicated features of a scene at a glance.

◆ **Come together: perceptual averaging contributes to cueing effects**

- 70 H M Krueger, W J MacInnes, A R Hunt (University of Aberdeen, UK; e-mail: h.m.krueger@abdn.ac.uk)

An uninformative exogenous cue speeds target detection if the cue and target appear in the same location separated by a brief temporal interval. This finding is traditionally ascribed to the orienting of spatial attention to the cued location. Here we examine the role of perceptual averaging of the two trial events in speeded target detection. That is, the cue and target may be perceived as a single event if they appear in the same location and therefore the perceived target onset is temporally bound to the earlier cue onset. We measured manual reaction times to detect cued and uncued targets, and observed the traditional facilitation of cued over uncued targets. We asked the same observers to judge target onset time by

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noting the time on a clock when the target appeared. Observers consistently judge the onset time of the target as being earlier than it appeared, with cued targets judged as earlier than uncued targets. When the cue-target order is reversed so that the target precedes the cue, perceived onset is highly accurate in both cued and uncued locations. These findings suggest that perceptual averaging, in addition to attentional orienting, can contribute to cueing effects.

◆ **Suppression of color cues depends on stimulus size**

71 J G Schönhammer, D Kerzel (Université de Genève, Switzerland; e-mail: Dirk.Kerzel@unige.ch)
In spatial precue paradigms with non-predictive cues, discrimination responses are usually faster to cued than to uncued locations at onset asynchronies shorter than 200 ms. When cues and targets are singletons with different features, responses to cued and uncued locations are equally fast. However, recent studies occasionally found slower responses to cued than to uncued locations, indicating suppression of the cued location (eg, Anderson and Folk, 2010 *Attention, Perception, and Psychophysics* **72**(2), 342–352). Experimental manipulations and underlying processes connected to these effects are still unclear. We varied color and size of cue singletons, in situations where target singletons had a different color than the cue. Suppression effects were observed when cues were small. When the size of the cues was increased, responses were equally fast to cued and uncued locations. This suggests that suppression effects depend on stimulus factors as well as the features observers are set to respond to.

◆ **Localized oscillatory activity in the human attention network in response to predictive and unpredictable visual cues**

72 I Dombrowe, C C Hilgetag (ICNS, Universitätsklinikum Hamburg-Eppendorf, Germany; e-mail: idombrowe@gmail.com)

People orient attention towards stimuli in their visual field with the help of a bilateral network of regions mostly in the frontal and parietal lobes. The areas within this network communicate through synchronized neural activity. To study the dynamics of this network during orienting, neural activity can be non-invasively measured by electroencephalography (EEG) and perturbed by transcranial magnetic stimulation (TMS). In the present study, participants performed a visual cueing task while their EEG was recorded. The cue was either unpredictable (block A: 50 % cue validity) or predictive (block B: 67% cue validity) with regard to target location. Corresponding to these conditions, we found distinct patterns of oscillatory activity in the alpha, beta and gamma bands, which was lateralized and topographically confined and helps to reveal targets for regionally and frequency-specific perturbation by TMS.

◆ **A neurodynamical model for contrast-invariant and scale-invariant contour grouping**

73 I Korjoukov, P Roelfsema (Netherlands Institute for Neuroscience, Netherlands; e-mail: i.korjoukov@okazolab.com)

We present a neurodynamical network model to study mechanisms of contour grouping in vision. The model resembles the organization of the visual cortex: a hierarchy of areas, feedforward and recurrent connectivity and feature-specific tuning. The model has two processing stages: in the initial, feedforward, stage the model carries rapid recognition of familiar contour configurations, whereas in the late, recurrent stage, the model incrementally builds a reliable grouping code for any arbitrary configuration selected by visual attention. The two stages are modeled with simple and realistic single-unit dynamics that is modulated by attention and not disrupted by variations in input contrast. The model offers a plausible computational account for contrast-invariant and scale-invariant perceptual grouping.

◆ **Task congruency in inattention blindness**

74 N Adamian, M Kuvaldina (St.Petersburg State University, Russian Federation; e-mail: kuvaldinamara@gmail.com)

Some works on Inattention Blindness (IB) have explored the inhibition hypothesis which states that IB arises from some feature-based (Andrews et al, 2011 *Journal of Experimental Psychology* **37** 1007–1016) or space-based (Thakral, Slotnick, 2010 *Consciousness and Cognition* **19** 636–643) inhibition. Our hypothesis is that this inhibition occurs due to the contextual incongruence of the critical object. To prove this we tried to manipulate the degree of contextual expectancy/congruency in a series of experiments. In a modified paradigm of IB we use lexical stimuli and control the level of subjects' expectancy of the critical stimulus. Subjects were asked to solve an anagram presented for 200 msec. After several trials two new letters were added so that the anagram could be solved in two ways: by using only the main letters or by adding two new letters. Corpus frequency and word form of anagrams as well as task-congruency of critical stimuli were varied. The results showed that in that task-incongruent,

low-frequent and improper form conditions the level of IB significantly increased. We explain this effect as a result of inhibition of the new stimuli that are inconsistent to the general target representation, and discuss it in terms of inhibition hypothesis of IB.

◆ **Visual search for letters within words and nonwords in the right and left visual hemifields**

75 E Gorbunova, M Falikman (Lomonosov Moscow State University, Russian Federation; e-mail: gorbunovaes@gmail.com)

Although visual search for letters within words has been investigated in a number of studies, there is no agreement on whether there is a word superiority effect in such search as compared to search within meaningless letter strings (nonwords). In our experiments, observers searched for a prespecified letter in displays containing pairs of 6-letter words or nonwords placed left and right to the fixation, with a variable target letter position within word and nonword strings, but constant absolute distance between fixation and a target letter. The RT data collected from 28 participants demonstrate a significant interaction of all three experimental factors (visual hemifield, letter string type and target letter position, repeated measures ANOVA, $p < 0.002$) and provide evidence for serial search for a letter within a word in the left visual hemifield and within a nonword in the right visual hemifield and, surprisingly, parallel search for a letter within a nonword in the left visual hemifield and within a word in the right visual hemifield. This pattern of results might reflect hemispheric differences in lexical information processing, together with the hemispheric asymmetry in selective visual attention.

◆ **Metacognitive regulation of the dead zone of attention**

76 Y M Stakina, I S Utochkin (Nanional Research University Higher School of Economics, Russian Federation; e-mail: staulia@mail.ru)

The dead zone of attention (DZA) was previously found in change blindness paradigm and described as exaggerated inability to see a change near the center of interest in a scene (Utochkin, 2011 *Visual Cognition* 19 1063–1088). Here we tested a hypothesis that DZA can at least partially be explained as a consequence of a spontaneous search strategy that makes attention to avoid regions near center in favor of larger skips. We manipulated search strategy at metacognitive level by informing observers what DZA is and making them use this information to improve performance. Like in earlier experiments by Utochkin, observers looked for a marginal change near or far from a once noticed central change. In experiment 1, only one marginal change occurred per a trial, in experiment 2 both changes were placed in competition. We compared results with earlier Utochkin's results without informing about DZA. DZA informing had no effect on search time (experiment 1) or probability of prior detection (experiment 2) but reduces the number of errors in near condition. Our results suggest that metacognitive regulation of DZA is limited. It appears that it has no effect on global search strategy. Yet, it improves deployment of attention within DZA itself. [The study was implemented within the Programme of Fundamental Studies of the Higher School of Economics in 2012.]

◆ **Neural mechanisms of feature attention revealed by frequency tagging in MEG**

77 D Baldauf, R Desimone (MIT, USA; e-mail: baldauf@mit.edu)

We used a frequency tagging paradigm to study brain networks mediating feature attention. The stimuli were sequences of compound images of faces and houses flickering at different tagging frequencies. Our fMRI-guided analysis of the MEG/EEG signals revealed a network of areas in frontal and temporal cortex that closely followed the attended stimulus' frequency at differential phase lags. We further analyzed interactions between the involved brain areas by means of neuronal synchrony and coherence across the spectrum, and we cross-validated the observed functional connectivity with each participant's individual tractography. Our results imply that the inferior frontal gyrus provides attentional top-down signals to stimulus-tuned temporal areas by engaging into coherent oscillations.

◆ **Visuospatial awareness is modulated by dual-task demands: evidence from healthy participants and right hemisphere damaged patients**

M Bonato¹, M Lisi¹, C Spironelli¹, K Priftis², C Umiltà¹, M Zorzi¹ (¹University of Padova, Italy; ²University of Padova and Laboratory of Neuropsychology, IRCCS San Camillo, Lido-Venice, Italy; e-mail: mario.bonato@unipd.it)

We studied the modulation of visuospatial awareness—and the resultant asymmetries across visual hemifields—induced by a dual-task manipulation that consumed the attentional resources available for spatial monitoring. Reaction times and detection rates for lateralized, briefly-presented, masked or unmasked visual target(s) were assessed in healthy participants and right-hemisphere damaged

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patients. In the single-task condition, participants had to report only the position of the target(s) ("right", "left", or "both" sides). In the dual-task conditions, while monitoring for target(s) onset, they performed also a second task, visual or auditory, to increase the cognitive load (Bonato et al, 2010 *Neuropsychologia* **48** 3934–3940). Healthy participants showed increased hemifield asymmetries under dual-task, suggesting a key role for aspecific attentional resources in spatial monitoring. Right-hemisphere damaged patients (tested without masking) showed severe contralesional awareness deficits, that is neglect and extinction under both dual-task conditions. Thus, important asymmetries in spatial awareness emerge when attentional resources are consumed by a concurrent task, loading either on visuospatial or on working-memory resources. For patients, this turns into a contralesional awareness deficit that is pathognomonic for neglect even when they appear intact on clinical tests. Implications for the mechanisms subtending normal and pathological attentional orienting and spatial awareness are discussed.

◆ **Feature based attention across eye movements**

79 D Jonikaitis¹, H Deubel¹, J Theeuwes² (¹Ludwig Maximilians University, Germany; ²Vrije Universiteit Amsterdam, Netherlands; e-mail: Djonikaitis@yahoo.com)

Primate visual system has been shown to compensate for eye movement induced retinotopic shifts in the visual image. For instance, neurons with receptive fields coding for post-saccadic retinotopic stimulus location are activated even before a saccade starts. Similarly, spatial attention also predictively shifts to the post-saccadic stimulus location. Such predictive updating of spatial location information is considered to be the mechanism mediating visual stability. However, contributions of attended object features—such as shape or color—have been relatively neglected. We investigated feature based attention across saccades and its potential contributions to visual stability. In this study, we asked participants to do two things at the same time—to make a saccade to a colored dot and to discriminate a probe (a Gabor patch tilted to left or right) presented at a distractor location which either matched or did not match the color of the saccade target. Tilt discrimination performance hence served as a measure of feature based attention—before a saccade started, participants were better at discriminating probes presented at distractor locations that matched the color of the saccade target, than at distractor locations that did not match that color. This is a classic feature attention effect—allocating attention to one feature (color of the saccade target) lead to performance increases at other locations matching that feature (distractor locations matching that color). Importantly, we observed that immediately after the saccade was finished, feature based attention benefits persisted at the distractor location with matching color, regardless of the fact that it now had a different retinotopic position. Thus, feature based attention and predictive shifts of spatial attention could combine to quickly find the location of relevant objects across saccades.

◆ **Working memory load influences on attention process of the emotional task-irrelevant information**

80 E Matsumoto (Kobe University, Japan; e-mail: ermatsu@kobe-u.ac.jp)

In the everyday activity, attention is easily disturbed by the environmental stimuli and information which are irrelevant to the current purpose of the behavior. In the previous studies reveals that task-irrelevant information processing depends critically on the level and type of load involved in the processing of goal-relevant information. Whereas high perceptual load can eliminate distractor processing, high load on higher cognitive control processes like working memory increases distractor processing (Lavie, 2005 *Trends in Cognitive Science* **9**(2), 75–82). In the present study, we manipulated working memory load using by n-back task, and examined whether the emotional faces affect executive cognitive process although those are completely task-irrelevant. Angry, neutral and happy faces were presented peripheral as task-irrelevant stimuli. Participants were informed that those faces had no relation to the task, and they asked to ignore the faces. The results showed the differential effect of load level and emotion. When the working memory load was high, the error rate was increased especially angry face was appeared as task-irrelevant stimulus. The result suggests that ignoring the threatening related emotion required more executive resource rather than rejecting other emotions.

◆ **Is there a spatial representation of non-symbolic numerical quantities?**

81 G Tamburini, A Fumarola, R Luccio, T Agostini (University of Trieste, Italy; e-mail: giorgia.tamburini@phd.units.it)

The Spatial Numerical Association of Response Codes (SNARC) showed the existence of an association between number magnitude and response position (Dehaene et al, 1993 *Journal of Experimental Psychology: General* **122** 371–396). Recently, it has been investigated the spatial representation of

non-symbolic numerical quantities (dots) using a line bisection task (de Hevia and Spelke, 2009 *Cognition* **110** 198–207; Gebuis and Gevers, 2011 *Cognition* **121** 248–252) but the results are not agree. We investigated whether there is the spatial association between non-symbolic numerical quantities (dots) and response position using a simple detection experiment (Fischer et al, 2003 *Nature Neuroscience* **6** 555–556). The dots was used as prime and it appeared at the centre between two lateral boxes. The participants' task was to respond by pressing the space bar as soon as they detected the target which appeared after the prime. The target was a grey square that appeared in one of two boxes. Results showed RTs faster for small quantities associated with the left target and for big quantities associated with the right target. Our data support the idea that the non-symbolic quantities have a spatial representation, in the form of a left-to-right oriented mental line.

◆ **Abnormal attentional masking in children with specific language impairment**

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In order to become a proficient user of language, infants must detect temporal cues embedded within the noisy acoustic spectra of ongoing speech by rapid attentional engagement. According to the neuro-constructivist approach, a multi-sensory dysfunction of attentional engagement—hampering the rapid temporal sampling of stimuli—might be responsible for language deficits typically shown in children with Specific Language Impairment (SLI). In the present study, the efficiency of visual attentional engagement was investigated in 22 children with SLI and 22 typically developing (TD) children by measuring attentional masking (AM). AM refers to impaired identification of the first of two sequentially presented masked objects (O1 and O2) in which the O1-O2 interval was manipulated. Children with SLI showed a deeper AM and more sluggish AM recovery. Our results suggest that a multi-sensory engagement deficit—probably linked to a dysfunction of the right fronto-parietal attentional network—might impair language development.

◆ **The dynamic-updating hypothesis: Attentional selection of dynamically changed objects**

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While there is a time delay between the appearance of an object and our awareness of it, maintaining the most updated information in the constantly changing visual world is crucial for survival. Previous theories of object-based attention mainly derived from studies using objects of fixed boundaries. This constrained these theories to such objects. We proposed a dynamic-updating hypothesis for object-based attention: Object representation-after being attended-still undergoes a constantly and continuously updating process as long as the physical object is present. To test this, in a modified double-rectangle cueing paradigm, we changed the object display after one of the objects was cued. In a speeded detection task, the attended object was either changed globally (grouped with the other object via amodal completion), or locally (changed its shape via boundary change), or disappeared and then reappeared, or maintained blank at the target frame. Object-based attention remained-a shorter reaction time for the target appearing on attended than on unattended object-when the originally cued object was changed or reappeared, but not when it disappeared at the target frame. This suggests that object representation that attention has selected undergoes dynamic reorganization constantly and continuously, supporting the dynamic updating hypothesis.

◆ **On color and emotion: An ERP study of visual attention**

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Research problem Delineation emotional from neutral stimuli occurs at very early stages of visual information processing, which manifests in facilitation of capturing attention by affective images. One of the basic features modulating this process might be the coloring of stimuli. In particular, the red color, due to its evolutionary importance, may serve as a cue governing attention and facilitating processing of red objects. Method Using dot-probe paradigm we briefly presented pairs of IAPS (International Affective Picture System) images of equal valence (positive, negative or neutral). Each pair consisted of one picture featuring prominent red dominant and the other in non-red coloring, with brightness and contrast adjusted. The following target-dot was flashed either on the side of the red picture (congruent condition) or non-red picture (incongruent condition). Procedure included EEG signal recording and reaction time measurement. Results P1 component was modulated solely by valence of the cue, with positive and negative cues yielding larger amplitudes than neutral cues. N2pc component was sensitive to both emotional valence and color, being more negative contralateral to the red picture but only in case

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of emotional stimuli. At the behavioral level, reaction times were shorter in congruent as compared to incongruent condition, especially for emotional pictures. **Conclusions** The results suggest that affective valence of the stimulus is evaluated extremely fast regardless of coloration. However, the red dominant acts as an attractor on the later stages of visual processing capturing visual attention and eventually facilitating motor response.

◆ **Variation of attentional capture by transient luminance changes over repeated exposure**

85 M I García-Ogueta (Universidad de Salamanca, Spain; e-mail: ogueta@usal.es)

It's well-known that transient luminance changes even irrelevant to the task capture attention. In previous research we got attentional capture effects on locations congruent or incongruent with the subsequent stimuli locations, causing benefits and costs respectively. Our aim in the present research is to know whether attentional capture changes as a function of repeated exposure to capture trials and if this repeated exposure affects in a different way to congruent and incongruent capture or whether it depends on the stimulus asynchrony (SOA) between capture and stimuli onset. We also considered different perceptual load conditions. Our results showed accuracy costs of incongruent capture not only for 64 or 128 attentional capture trials exposure but also for 192 and even 256 trials exposure, in a 165 ms. asynchrony condition. However RT costs only remained for the first 64 capture trials. In case of congruent capture, RT benefits remained through the whole series of capture both with a long (165 ms.) and a short asynchrony (110 ms). Effects of perceptual load should also be taken into account to explain results.

◆ **Effects of mood induction on eye movement inhibition: An antisaccade task with emotional faces**

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We investigated the effects of mood on eye movement inhibition in an antisaccade task. After a mood induction procedure (MIP) in which participants watched a film (ie, positive, negative or neutral), the antisaccade task required them to generate saccades in the opposite hemifield to emotional faces (ie, sad, happy or neutral) appearing on the left or right of a central fixation point. Measures of pupil size and subjective rates were carried out both before and after MIP, and confirmed that participants' mood was significantly different between the three MIP conditions. Results showed that participants had more correct antisaccades following the presentation of sad faces than following the presentation of happy or neutral faces. These results are congruent with a hedonic perspective in which individuals automatically avoid negative stimuli and look for more positive stimuli in order to optimize their mood. Moreover, the longer antisaccade latencies observed in positive and negative mood inductions, compared to the neutral mood induction, suggest that individuals in positive or negative moods could have more difficulty in inhibiting eye movements, and more generally indicate that mood moderates inhibitory attentional control.

◆ **Is the relevance of the critical object irrelevant for the Inattentional Blindness?**

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One of the distinctive features of the Inattentional Blindness (IB) experimental paradigm is the critical object irrelevance that makes it easy for the subject not to notice it (Most et al, 2001 *Psychological Science* **121**, 9–17; Koivisto, Revonsuo, 2008 *Psychological Research* **72** 39–48). But if some features of to-be-attended objects are primed in the procedure, the probability of noticing these more relevant stimuli in the IB task could be increased. To test this we explored the influence of relevance of the critical object on the IB level in the following ways: (1) increasing expectations about the appearance of the critical object by enumerating its features right before it appears in the task (2) providing prime by making targets transform to the shape of the critical object right before it appears in the task (3) matching the trajectory of the critical object to the trajectory of targets. All experiments used a sustained IB procedure. The IB rate observed was not different from the control conditions in which none of the above experimental manipulations took place. These results support the idea of the feature-based inhibition in IB (Andrews et al, 2011 *Journal of Experimental Psychology* **37** 1007–1016).

◆ **Singleton-detection or Feature-search: Working memory capacity may be the thing, wherein we'll catch attention with a ring**

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When searching for a uniquely-coloured target in a RSVP stream of homogeneously-coloured distractors, observers can use one of two search modes: singleton-detection or feature-search. Using an attentional-capture paradigm, we varied (a) the number of possible target colours from 1 to 4, in experiments 1–4 respectively, and (b) the appearance of a coloured ring around one of the distractors in the RSVP stream. When present, the ring was either the same colour as one of the possible target colours (Colour-Match), or an irrelevant colour (Colour-Mismatch). Capture was measured as the impairment in target identification accuracy when the ring was present relative to when it was absent. Greater capture in the Colour-Match than in the Colour-Mismatch condition was regarded as evidence of feature-search mode. Equal capture in the two conditions was regarded as evidence of singleton-detection mode. Contrary to the common belief that singleton-detection is the default mode (Bacon and Egeth, 1994 *Attention, Perception & Psychophysics* 55(5), 485–496), we show that observers shift gradually from feature-search to singleton-detection mode as the number of target colours increases to four. This shift may be related to the capacity of visual working memory, estimated at three to four items (Luck and Vogel, 1997 *Nature* 390 279–281).

◆ **A rapid reaching task reveals the extraction of probability information from arbitrary colour cues**

89

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Our group has developed a novel technique for probing the earliest stages of motor planning by requiring participants to rapidly react to an array of potential targets, all of which have an equal probability of being cued as the final target. Deviations in initial trajectories mirror the 'global effect' observed in low-latency saccades when multiple targets or distractors are present. That is, the initial trajectories of reaches toward a field of potential targets reflect a fine-grained sensitivity to the probabilities inherent in the spatial distribution of targets. To investigate whether or not this fast system for planning reach direction is sensitive to other ways of communicating probability information, we used colour as a cue. Subjects quickly (< 325 ms) initiated reaches toward two potential targets, a green and a red circle. Subjects had to adjust their in-flight trajectories and hit the final target, which was cued only after the reach had been initiated. One of the target colours was 3 times as likely to become the final target. Initial trajectories were biased toward the high-probability target, regardless of final target location. These results indicate that the motor system can rapidly extract probability information from arbitrary colour cues and incorporate that information into the planning of reaches.

◆ **Attentional modulation of target location significantly affects pointing performance**

90

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The planning and execution stages of goal directed movements often rely on visual information about the target location. Cueing a target location can improve performance on a variety of tasks, indicating the representation of this information is enhanced by attention. However, it is not clear if attentional modulation of a cued location will also affect pointing performance. We asked observers to point to targets presented in noise with a signal to noise ratio that varied across blocks. Target locations were cued at different times in the reach to assess the effect of attentional modulation of target location on the planning and execution of a rapid goal directed movement. We measured movement latency, movement time and pointing precision, using a cue validity of 20% or 80%. Pointing precision improved with increasing signal to noise ratio. The cue was most effective in improving performance when it was presented early in the reach. The overall movement time was also significantly decreased when people pointed rapidly to a cued target, across all noise levels. The results suggest that the same visual representation that is modulated by visual attention is also used to plan and update rapid pointing movements.

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◆ **The effects of stimulus' representative consistency on inattentional blindness**

91 H Chen, Z Wang, Y Liu (Dept of Psychology, School of Education, Hebei Normal University, China; e-mail: chhzhen@163.com)

Three memory tasks were used to test the effects of the words and the pictures' representative consistency on inattentional blindness for unattended words showed in the selective-attention task. The recognition memory test was used to test whether the subjects occurred inattentional blindness for unattended words. The category association test and the perceptual identification test were used to test the priming level for the unattended words. The study adopted 2×2×3 within-subject design. The three factors were word type, consistency of semantic representation, and task type. The subjects were 31 college students, including 17 males and 14 females. The results showed that the subjects occurred inattentional blindness for the unattended words showed in the selective-attention task. In addition, compared to the unattended words whose semantic representation was not consistent with the pictures, the unattended words that had the same semantic representation with the pictures were more easily to result in the subjects' inattentional blindness. What's more, the unattended words that had the same semantic representation with the pictures processed not only perceptually but also conceptually, but the processing level of the unattended words whose semantic representation was not consistent with the pictures still need a further study. [The research was supported by Technology RandD Program of Hebei Province (Grant No. 11457202D-57), Natural Science Foundation of Hebei Province (Grant No. C2012205046) and Social Science Foundation of Hebei Province (Grant No. HB10VJY033).]

◆ **A neurocomputational account of mental curve tracing**

92 D Domijan (University of Rijeka, Croatia; e-mail: ddomijan@ffri.hr)

A neural model is proposed whose temporal dynamics simulates the properties of mental curve tracing. Behavioral studies revealed that the tracing is a time consuming process that serially spreads attentional label along the target curve. However, the speed of tracing is not fixed and it could be flexibly adjusted depending on the density of image elements. Single-unit recordings in the monkey primary visual cortex showed that tracing is associated with elevated firing rate for neurons whose receptive field falls on the traced curve. In order to explain behavioral and neurophysiological findings, the proposed model implements a novel form of neural filling-in that enables activity spreading along the target curve. Filling-in occurs at multiple spatial scales in order to account for different speeds of tracing. The model implements object-level competition and selection among distinct image elements. Computer simulations showed that the model exhibits appropriate scaling of tracing speed with distance between curves thus simulating the hot spots of attention. The speed of tracing slows down when the curves are close to each other and speeds up when they are far apart. Furthermore, the model is able to store the traced pattern in short-term memory.

POSTERS: BIOLOGICAL MOTION

◆ **Categorizing identity from biological motion of eyes**

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Human body movements can provide rich cues to information about the person doing the movements, such as identity, gender, and emotions. Despite the fact that eye movements are also a kind of biological motion and our common belief that the eyes are the windows of our souls, it has not been clarified whether eye movements can convey one's individual character. We recorded the binocular eye movements of individuals while they made a short speech. A discriminant analysis of the physical parameters of the eye movements showed that motion information of the eyes conveys enough cues to mathematically discriminate the individuals. To examine whether we can know a speaker's identity from eye movements per se, we created computer-animated eyeballs from the recorded eye movement. Observers viewed the animations from four speakers and were asked to sort them into four groups on the basis of identity. They showed significantly better than chance performance. It is not likely that participants relied on eye blinks for identity judgment, because the accuracy was significantly reduced when the animation reproduced the frequency and length of the blinks. The results suggest that people can distinguish between individuals from motion information of the eyes alone.

◆ **Anticipation of action intentions in autism spectrum disorder**

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We investigated whether individuals with high-functioning autism spectrum disorder (ASD) are influenced by an agent's gaze direction when judging the agent's actions. Participants observed the agent's head rotate towards them, while the gaze direction was either leading, or lagging behind, head rotation. They also observed identical rotations of a cylinder containing the geometrical equivalent of the gaze manipulation. The typically-developed control group was influenced by the gaze manipulations in the animate stimulus: they overestimated the head rotation when gaze was ahead of rotation and underestimated it when gaze was lagging behind. For the inanimate stimulus there was no such effect. In contrast, the ASD group did not discriminate between the animate and inanimate stimuli; they showed a similar, weak, influence for both. This suggests that the ASD responses in the animate condition were determined by the low-level directional features of the eyes rather than by the conveyed intention to either continue to approach (gazed ahead), or to discontinue or slow down the approach (gaze lagging). We speculate that the reliance on low-level visual cues in the ASD group compensates for the inability to involuntarily extract the other's behavioural intentions as conveyed by gaze cues.

◆ **Evaluating observers' sensitivity to errors in virtual throwing animations**

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In everyday life, videogames, and movies, motions of human characters and inanimate objects are often in close spatiotemporal relation (eg, a throwing action of a baseball player). These events have not received much attention in human motion research. Using motion capture, we recorded an actor throwing a tennis ball with an over-arm or under-arm gesture, and transformed his actions into realistic virtual animations. The length of the parabolic trajectory was the same for both over-arm and under-arm throws, but the trajectory was slightly higher in under-arm throws. In this experiment, we manipulated the trajectory of the ball by increasing or decreasing its initial horizontal or vertical velocity at the time of release, and asked participants to judge if the animations were correct or incorrect. Our results show that observers are more sensitive to manipulations of the horizontal velocity for over-arm throws, but more sensitive to changes in vertical velocities for under-arm throws. In the latter case observers are more sensitive to decreases than to increases of velocity. This seems to show that the kind of gesture (over-arm vs under-arm) modulates observers' sensitivity to the incongruence between the virtual character's performance and the trajectory of the ball.

◆ **Exploring sensitivity to time-warped biological motion**

96 K Ryall¹, L Hoyet¹, J Hodgins², C O' Sullivan¹ (¹Trinity College Dublin, Ireland; ²Disney Research, Pittsburgh and Carnegie Mellon University, USA; e-mail: Carol.OSullivan@cs.tcd.ie)

In biological motion perception, it is often necessary to normalize certain factors, such as body shape or walking speed, in order to vary them methodically. For example, in order to create an average motion, or to compute and compare quantitative metrics, it is necessary that sets of motions be aligned in time. For computer animation, a character's timing is often manipulated to achieve a desired result, in a process called time-warping. For our experiment, we captured movements from four actors (2M, 2F) walking at slow, medium and fast speeds. Thirteen participants viewed two virtual characters walking side-by-side at medium speed, one time-warped (faster or slower), the other unmodified. They were either displayed on a point-light walker or on a full geometrical model, each normalized for body shape. Accuracy and response times were recorded. Participants were more sensitive to time-warping when the slow motions were made faster than when fast motions were made slower (87% vs 63%, $F_{1,11} = 16.7$, $p < 0.005$). They were also more accurate with the geometrical model than with the point-light walker (80% vs 71%, $F_{1,11} = 6.4$, $p < 0.05$).

◆ **Spinal motor resonance by passive action viewing**

97 M H de Lussanet, F Behrendt, H Wagner (Westf. Wilhelms Universität Münster, Germany; e-mail: lussanet@wwu.de)

How do we avoid to make an action that we see? This question arose with the discovery of mirror neurons. It is thought that reflex gains change to avoid movements (Rizzolatti and Craighero, 2004 *Annual Review Neuroscience* 27 169–197). However, the modulation of reflex gain to seeing an action has never been measured for a condition in which it is known how the gain changes during active

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execution of the action. We evoked medium-latency cutaneous reflexes from the anterior tibial (TA) leg muscle, of which the activity and reflexes during walking are well known. We found that the gain changes are as during active walking: the reflexes were increased at the end of the stance phase and decreased at the end of the swing phase. This confirms that the gain of postural reflexes is under direct and dynamic control by the brain. More importantly, it provides the first evidence that reflex gains during seeing an action agree with active execution, rather than with suppression of movement. It is further unclear how we avoid to automatically perform the actions that we see. Moreover, the meaningful modulation of reflex gains might have important social functions, and to better understand actions that we see.

◆ **Recognition from facial motion in dynamic average avatars**

98 F Nagle, H Griffin, A Johnston (University College London, UK; e-mail: fusionlove@gmail.com)

Can we recognise a person by the way they change their expressions? Dynamic facial expression mimicry (in which one person copies the changing facial expressions of another) brings together the processes of perception, memory and motor control. Here we describe a method allowing near-photorealistic computational mimicry of a portrait video clip by an arbitrary target face. The output shows the target identity mimicking the source video clip. We also present a technique allowing blending of several target identities into a realistic “average avatar” which can be driven by portrait video clips. The technique exploits the face space paradigm for dimensionality reduction and representation of faces and the multichannel gradient model (Johnston, 1992 *Proceedings of the Royal Society of London B* **250** 297–306) for image registration. We show that near-photorealistic expression mimicry is possible and present experimental evidence that subjects can distinguish between known classmates and other individuals from the projection of the facial motion of these targets onto a dynamic average avatar.

◆ **Perceptual relevance of kinematic components of facial movements extracted by unsupervised learning**

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The idea that complex facial or body movements are composed of simpler components (usually referred to as ‘movement primitives’ or ‘action units’) is common in motor control (Chiovetto 2011 *Journal of Neurophysiology* **105**(4), 1429–31.) as well as in the study of facial expressions (Ekman and Friesen, 1978). However, such components have rarely been extracted from real facial movement data. Methods: Combining a novel algorithm for anechoic demixing derived from (Omlor and Giese 2011 *Journal of Machine Learning Research* **12** 1111–1148) with a motion retargeting system for 3D facial animation (Curio et al, 2010, MIT Press, 47–65), we estimated spatially and temporally localized components that capture the major part of the variance of dynamic facial expressions. The estimated components were used to generate stimuli for a psychophysical experiment assessing classification rates and emotional expressiveness ratings for stimuli containing combinations of the extracted components. Results: We investigated how the information carried by the different extracted dynamic facial movement components is integrated in facial expression perception. In addition, we tried to apply different cue fusion models to account quantitatively for the obtained experimental results. [Supported by DFG CU 149/1–2, GI 305/1–2, EC FP7-ICT grants TANGO 249858 and AMARSi 248311.]

◆ **Influence of crowding on discriminating the direction of biological motion**

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It is difficult to identify a target in the peripheral visual field when it is flanked by distractors. In the present study, we investigated this “crowding” effect for point-light biological motion perception. Three point-light walkers were presented horizontally in the periphery with various distances between them and observers reported the walking direction of the central figure. When the inter-walker distance was small, discriminating the direction became difficult. Moreover, the reported direction for the central target was not simply noisier, but reflected a pooling of the three directions. These results indicate that crowding occurs for biological motion perception. However, when the two flanking distractors were scrambled point-light walkers, crowding was not seen. This result suggests that the crowding in point-light biological motion perception occurs at a high-level of motion perception.

◆ **Physiologically plausible neural model for the recognition of dynamic faces**

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Facial expressions are essentially dynamic. However, most existing research has focused on static pictures of faces. The computational neural functions that underlie the processing of dynamic faces are largely unknown. Methods: We devised two alternative, physiologically plausible hierarchical neural models for the recognition of dynamic faces, which simulate the properties of neurons in face-selective regions such as the STS: (1) an example-based model with units, embedded in a recurrent network that is selective for the temporal order, encoding key frames of the expression sequence, and b) a norm-referenced model based on neurons that encode deviations from the neutral face ("norm stimulus") in feature space. Both models are based on an extension of a neural model for the recognition of static faces by (Giese and Leopold, 2005 *Neurocomputing* **65–66** 93–101). They were tested on movies from rhesus monkeys showing 'threat' and 'coo-call' expressions. Results: Both models work successfully and classify monkey expressions in real videos correctly. They make different predictions about the properties of face-selective single cells, eg those in the STS. Conclusions: Simple physiologically plausible neural circuits can account for the recognition of dynamic faces. Data from single-cell recordings will be required to decide between different models.

◆ **Auditory signal dominates visual in the perception of emotional social interactions**

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Multimodal perception of emotions has been typically examined using displays of a solitary character (eg the face-voice and/or body-sound of one actor). We extend investigation to more complex, dyadic point-light displays combined with speech. A motion and voice capture system was used to record twenty actors interacting in couples with happy, angry and neutral emotional expressions. The obtained stimuli were validated in a pilot study and used in the present study to investigate multimodal perception of emotional social interactions. Participants were required to categorize happy and angry expressions displayed visually, auditorily, or using emotionally congruent and incongruent bimodal displays. In a series of cross-validation experiments we found that sound dominated the visual signal in the perception of emotional social interaction. Although participants' judgments were faster in the bimodal condition, the accuracy of judgments was similar for both bimodal and auditory-only conditions. When participants watched emotionally mismatched bimodal displays, they predominantly oriented their judgments towards the auditory rather than the visual signal. This auditory dominance persisted even when the reliability of auditory signal was decreased with noise, although visual information had some effect on judgments of emotions when it was combined with a noisy auditory signal. Our results suggest that when judging emotions from observed social interaction, we rely primarily on vocal cues from the conversation, rather than visual cues from their body movement.

◆ **"Ne me quitte pas": An anxiety-induced bias in the perception of a bistable walker?**

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Bistable figures can serve as exquisite stimuli to study top-down (non-sensory) influences in perception, because bottom-up information can be kept constant while categorically different percepts are experienced. There is ample evidence for these influences in object formation. For example, Peterson (1994 *Current Directions in Psychological Science* **3**(4) 105–111) reports that we segment figure from background in face/vase-like stimuli depending on the meaningfulness of the segments. We tend to see meaningful segments as the foreground object. In this experiment we looked at whether the trait social anxiety of the viewer can bias perception of a bistable point-light walker, since its different percepts have different intrinsic emotional relevance (walking towards you or away from you). We found that people with high social anxiety have a bias towards seeing the point-light figure walking away from them, compared to people with low social anxiety. In a separate emotional dot probe experiment we confirmed that there was a difference in anxious behaviour between our groups. We discuss these results in the context of previous studies on emotion-induced differences in perception and explore possible alternative explanations.

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◆ **Judging time-to-passage of biological motion in periphery**

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In time-to-passage judgments the complexity of the motion pattern plays a more determinant role than the “biologicity” of the stimulus. Articulated stimuli were judged as passing sooner than rigid stimuli but reflected more uncertainty in the judgments as revealed by precision judgments and required longer reaction times (Mouta et al, 2012 *Journal of Vision* 12 1–14). It is known that periphery can perceive biological motion (Thompson et al, 2007 *Journal of Vision* 7(10)12, 1–7). In the everyday life it is required to interact or estimate motion variables of other agents located on periphery. In this study, stimuli were presented in a more peripheral location (32°). In a time-to-passage (TTP) task rigid (RM) and biological (BM) motion conditions were compared. Subjects had to decide whether the point-light walker passed the eye plane before or after a reference time (1s) signaled by a tone. Subjects could judge time to passage of point-light-walker displays on periphery, although they need longer reaction times and they are less precise. Even so differences on the accuracy between BM and RM were vanished. The anticipation of the passage for BM was no longer found. Reaction time was significantly higher for BM. [Supported by FCT (SFRH/ BPD/ 63393/2009; PTDC/SAU-BEB/68455/2006); PSI2010–15867.]

◆ **An experimental-phenomenological study on perceived relations among mobile objects: the perceived social interactions among animate objects depends on the proximity of multiple objects in motion**

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Naïve observers can perceive some social interactions among the mobile toys that assume insect-like shape, namely small “head” and thick “body” with many “legs”, and that ambulate on some burred surface with oscillation made by built-in vibrator. According to expert observers’ description, these toys that named “HEX BUG nano” (TAKARA TOMY ARTS), naturally having neither brain nor voluntary intention, exhibit either integrative or segregative kinds of social or emotional interactions (Michotte, 1950) among them. To compare the free descriptions of expert observers with those of naïve subjects, some experiments were conducted as follows. (1) Motion pictures of the toys’ behavior recorded by down shot were presented to naïve subjects to collect free descriptions. (2) Computer programmed motion picture, in which black circles (that spoiled the insect-like shape of the toy) randomly displaced their positions, were presented to the other naïve subjects. Under both conditions, the observers shared descriptions of social or interactive relations among animate objects. The observers perceived relations among motions of multiple objects that didn’t assume any creature-like shape. The proximity of objects in motion was the necessary condition for perceiving such interactive relations.

POSTERS: CLINICAL VISION

◆ **Cortical mechanisms of discomfort in migraine**

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Migraineurs show subtle differences in perceptual sensitivity that have been attributed to cortical hyperexcitability. Coutts et al (Coutts, Cooper, Elwell, and Wilkins, in press *Cephalalgia*) found that the haemodynamic response at the offset of aversive visual patterns is more rapid in migraineurs than non-migraineurs. We measured contrast thresholds for aversion to drifting, vibrating and static patterns in migraineurs and headache-free controls. For both migraineurs and controls, drifting and vibrating patterns were more aversive than static patterns. Static patterns are epileptogenic in patients with photosensitive epilepsy; vibrating patterns are more so and drifting patterns less so (Binnie, Findlay, and Wilkins, 1985 *Electroencephalography and Clinical Neurophysiology* 61 1–6). There was therefore no simple relationship between the epileptogenic properties of the pattern and the aversion it evoked, even though, overall, the migraineurs showed greater discomfort than controls. We recorded the haemodynamic response to the patterns (using near-infrared spectroscopy). There were no differences in the amplitude of the haemodynamic response, but there was a steeper response at the offset of the

drifting pattern, which was the most aversive. Our findings suggest that this difference between grating patterns (and between migraineurs and controls as shown by Coutts et al) may reflect the aversion.

◆ **Neurological and neuropsychological characteristics of occipital stroke**

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We investigated a large number of stroke patients ($N=128$) to better characterize neurological and neuropsychological deficits caused by occipital damage. The aim was (1) a systematic description of subacute clinical and neuropsychological deficits and (2) to correlate the exact localization of lesions with specific perceptual deficits. Therefore we evaluated vision-related subjective and objective impairments by means of detailed anamnesis and clinical examination (such as Demtect, Rey-Osterrieth-Figure, Lang Stereo Test). Voxel-based lesion-symptom mapping (VLSM) was performed for those deficits appearing in at least ten patients. Subjectively, patients often reported visual field defects and phosphenes, as well as anomia, difficulties in reading and memory deficits. Visual disorders, such as achromatopsia, akinetopsia or prosopagnosia, were rarely reported. Objectively, a wide range of neuropsychological deficits were present. Visual field defects, reading disorders and the perception of phosphenes were associated with lesions of the calcarine sulcus. Anomia was associated with lesions of the occipital inferior gyrus while memory deficits were correlated with damage to the lingual gyrus and the hippocampus. Overall, we provide detailed descriptions of neurological and neuropsychological symptoms, infarct topography and the behavioral-structural relationship, as revealed by VLSM. The results underline the clinical relevance for neurological and neuropsychological assessments after occipital stroke.

◆ **Vision among sight recovery patients with various visual experience**

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Sight recovery patients, both with acquired (Sikl et al, submitted) or congenital (Fine et al, 2003; Ostrovsky et al, 2006, 2009) blindness, show deficits particularly in the domains of face perception, visual space perception and object recognition. However, many patients with acquired blindness gain visual experience during short sight recovery periods, ie, their blindness is repeatedly interrupted. It is not well known how these "interruptions" facilitate patients' capacity for post-treatment improvement. We examined three sight-recovery patients with acquired blindness who differed in terms of period of blindness, and also in terms of presence of those short sight recovery periods during their blindness. Various experimental tasks examining above mentioned afflicted areas were used. The results illustrate that the patient with a continuous (uninterrupted) period of blindness shows remarkably impoverished performance especially in the domain of object recognition in sub-optimal conditions in comparison with two other patients with interrupted visual deprivation. The findings implicate the importance of short visual periods in maintenance of rich and robust visual representations in post-treatment visual development.

◆ **Investigating the connectivity and integrity of visual pathways following damage to V1**

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Few studies have investigated functional or structural connectivity in the visual pathway following visual cortex damage in adulthood. GY, who sustained left V1 damage aged 8 reportedly showed altered connectivity of thalamocortical and cortico-cortical visual pathways when compared to controls. The authors suggest this may indicate plasticity within the visual system. It remains unclear, however, whether any such structural changes are necessary for visual function, or indeed whether such changes are possible when damage occurs in adulthood. We recruited four patients with chronic V1 damage sustained in adulthood, three of whom showed BOLD activation of ipsilesional V5/MT with motion stimuli presented in the blind hemifield. We used diffusion-tensor imaging (DTI) to look for the presence of tracts subserving V5/MT, and to measure tract integrity. In both patients and age-matched controls we found pathways between V5/MT and LGN, as well as superior colliculus. Despite activation of V5/MT, the integrity of these pathways was impaired (mean FA = 0.368 vs 0.462 controls, 95%CI = -0.139, -0.04). Cortico-cortical connections between V5/MT bilaterally were present only in patients demonstrating V5/MT activation and tract numbers were significantly greater than controls (normalized

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mean=403.0 vs 42.3, 95% CI = 27.78, 693.6). Employing DTI to investigate changes in connectivity may uncover possible structural changes underlying blindsight.

◆ **In schizophrenia patients, high-level but not low-level motion processing is impaired**

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One of the prominent perceptuo-motor deficits in schizophrenia patients is the inability to perform smooth-pursuit eye-movements. While recent studies have shown that frontal motor areas as FEF are rather unaffected and that higher-order motion computation in area MT (motion integration, speed discrimination and conscious motion perception) is highly impaired, it has remained unclear whether also low level motion processing in V1 is compromised. Here we contrast performance of schizophrenia patients with normal controls in two tasks. In the first experiment, low-level motion information defines the figure in a figure-ground segregation task. In the second, similar motion information defines events that have to be used in a temporal order judgment task. While solving the first requires processing in V1 and the ventral pathway (unaffected in Schizophrenia), the second relies on processing in V1 and the dorsal pathway (compromised in Schizophrenia). Results show that patients' thresholds are greatly prolonged in the judgment task but only mildly impaired in the segregation task. As both tasks rely on the same low-level motion information the good results in the segregation task demonstrate that low-level motion processing is relatively spared in Schizophrenia. This result restrains the locus of the impairment in Schizophrenia to areas beyond the primary visual cortex and thus contributes to a finer localization of the deficit. For visual neuroscience, in turn, the findings add further evidence to the notion that also motion-defined figure-ground segregation is processed in the areas of the ventral pathway.

◆ **Measurements of contrast sensitivity functions show recovery from extended blindness**

111 A Kalia¹, L Lesmes², M Dorr², P Bex², T Gandhi¹, P Swami³, G Chatterjee¹, P Sinha¹ (¹MIT, USA; ²Schepens Eye Research Institute, USA; ³National Institute of Technology, Rourkela, India; e-mail: aakalia@gmail.com)

We report on the recovery of vision in ten patients who were treated for early onset (< 1 year) cataracts after long-term deprivation (8–15 years). Unlike previously reported cases of sight restoration (Fine, et al, 2003; Maurer, Ellemberg and Lewis, 2006), we had the opportunity to study a large number of patients in India who were blind since early in life and treated past the age for normal development of contrast sensitivity (Project Prakash). Patients ranged in age from 8 to 17 years and were treated 3 months to 2 years prior to testing. We used Lea symbols as stimuli and a Bayesian adaptive method to estimate contrast sensitivity functions (Lesmes et al, 2010). Results show that all patients recovered some vision in the lower spatial frequency range, and some patients even showed peak sensitivities (thresholds<1%) that were equivalent to sighted controls, but shifted to lower frequencies. The age, level of pre-operative vision (light perception vs finger counting), and time since treatment did not predict the extent of recovery. These results suggest that the human visual system has the potential to develop contrast sensitivity after long-term deprivation, but it is still unknown which factors influence the extent of recovery.

◆ **How does the optical quality of the eye affect letter recognition and reading? Task-specific effects are revealed for optical distortions of text**

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The optical components of the eye have inherent imperfections that degrade the image falling on the retina. Simple examples are defocus and astigmatism, which are routinely corrected, but higher-order aberrations remain. These optical distortions can have dramatic effects on the retinal image; making letters more difficult to identify and potentially making one more similar to another. We imposed defocus, coma and secondary astigmatism (higher-order astigmatism) in the rendering of text. The types of aberration can be compared on the same scale via an index of confusability based on letter-by-letter cross-correlation. These aberrations have qualitative differences: defocus and secondary astigmatism primarily affect letter form while coma smears the text in one direction whilst leaving the form relatively intact. In one experiment we measured subjects' contrast thresholds for single-letter identification and in another we measured reading performance (average fixation duration over a sentence). Defocus and secondary astigmatism specifically disrupted word recognition whereas coma did not. Coma was particularly disruptive with letter strings since in reading (but not letter identification) equivalent

impairment occurred at lower confusability. This was possibly caused by crowding or disruptions to saccade planning since coma tends to fill in the spaces between letters and words.

◆ **Beyond blindsight: perceptual re-learning of visual motion discrimination in cortical blindness improves static orientation discrimination**

113 A Das, K R Huxlin (Flaum Eye Institute and Centre for Visual Science, University of Rochester, USA; e-mail: anasuya_das@urmc.rochester.edu)

Damage to the primary visual cortex or its immediate afferents results in a dense scotoma, termed cortical blindness (CB). A majority of CB subjects however, still retain the ability to detect stimuli that have high temporal and low spatial frequency content. Furthermore, recent work from our lab as well as others has shown the effectiveness of repeated perceptual stimulation in shifting the blindfield border. Specifically, we showed that global direction discrimination training restores direction integration at the trained, blindfield locations. Broad transfer of learning was observed across different moving stimuli. We asked whether visual motion relearning is specific to motion stimuli or whether it transfers to non-motion stimuli that traditionally do not elicit blindsight. We trained CB subjects on a global direction discrimination task in their blind field until they recovered normal direction integration thresholds. Contrast sensitivity for orientation discrimination of static gabors was measured pre- and post-training at the same locations. Motion training improved contrast sensitivity for static gabors presented at the training location, with greater improvements at spatial frequencies lower than 5cpd. Orientation difference thresholds also improved significantly for low frequency (0.5cpd) static gabors. These results suggest that perceptual learning in cortically blind fields generalizes to a broader range of stimuli than predicted by blindsight alone.

◆ **Effects of cloudiness on reading: A comparative experiment on the contrast polarity effect using a cloudy ocular media simulation-**

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Legge et al (1986) showed that reading performance is higher with white letters on a black background (white-on-black; W/B) than black letters on a white background (black-on-white; B/W) in eye disorders with cloudy ocular media. In this research, cloudy ocular media was simulated with a Bangerter filter, and an examination was conducted using MNREAD-J of which aspects that white/black inversion has an effect on (eg, logMAR acuity, reading acuity, critical print size, maximum reading speed). The participants were 12 adults with normal visual function. Results of a *t*-test showed that for logMAR acuity, reading acuity, and critical print size, the white/black inversion condition exhibited significantly higher performance, but there was no difference in maximum reading speed. Also, the difference in performance was greatest for logMAR acuity (B/W condition 0.49, W/B condition 0.23), followed by reading acuity (B/W condition 0.45, W/B condition 0.32) and critical print size (B/W condition 0.73, W/B condition 0.60).

◆ **Training on lateral interactions improves peripheral visual acuity in patients with macular degeneration**

115 M Maniglia¹, G Campana¹, A Pavan², D Guzzon¹, C Casco¹ (¹Dept of General Psychology, University of Padua, Italy; ²SISSA, Italy; e-mail: clara.casco@unipd.it)

People suffering from macular degeneration are forced to use a new fixation point in the peripheral visual field (preferential retinal locus-PRL) for visual tasks previously performed by the macula. However, besides a different pattern of connectivity in the retina, the peripheral visual field is characterized, respect to the central visual field, by stronger inhibitory lateral interactions between detectors at early levels of cortical processing, which hampers visual resolution. Here we investigated whether training on lateral interactions could weaken these inhibitory interactions and whether learning transferred to untrained, higher-level visual functions (acuity, crowding). We previously reported that modulation of lateral interactions in the periphery with perceptual learning reduced crowding in normal-sighted subjects. Training consisted in a contrast detection of a Gabor target with iso-oriented high contrast Gabor flankers, at different target-to-flankers separations. Training increased contrast sensitivity at all separations, and, despite not having any effect on crowding, improved visual acuity and contrast sensitivity at the trained spatial frequencies. The absence of crowding reduction could be due to a different pattern of connectivity respect to normal-sighted subjects, resulting from the loss of central

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vision. Nevertheless, the improvement of visual acuity opens new perspectives for the rehabilitation of patients with macular degeneration.

◆ **Could contrast-modulated optotypes aid in the detection of amblyopia?**

116 S J H Lalor, M A Formankiewicz, S J Waugh (Anglia Ruskin University, UK; e-mail: sarah.lalor@anglia.ac.uk)

Amblyopes show a specific loss of sensitivity to contrast-modulated stimuli and are thought to suffer more from crowding. Stronger contour interaction/crowding has been found for detecting large contrast-modulated (CM) letters, than for luminance-modulated (LM) letters (Chung et al, 2007 *Journal of Vision* 7(2) 1–13); and for visual acuity using CM rather than LM Cs (Hairol et al, 2010 *Journal of Vision* 10(7) 1332). Neither crowding, nor contour interaction, has been investigated with luminance-modulated and contrast-modulated, child-friendly optotypes. Contour interaction was assessed for LM and CM Kay Pictures, Lea Symbols and HOTV optotypes for normal adult observers. Visual acuity, with and without surrounding contours, was measured using a method of constant stimuli and contour separations of 0 to 10 stroke-widths. A repeated measures ANOVA with Greenhouse-Geisser correction found the magnitude of contour interaction to be significantly larger (at $p < 0.05$) for CM optotypes (~1 line of acuity loss) than for LM optotypes (~0.5 line of acuity loss). The extent of crowding (in stroke widths) was not significantly different for the two stimulus types ($p > 0.10$). The larger magnitude of contour interaction, combined with a specific loss of sensitivity to contrast-modulated stimuli in amblyopia, may mean that contrast-modulated optotypes could aid in amblyopia detection.

◆ **The effects of termination rules on contour interaction in a resolution acuity task with luminance-modulated and contrast-modulated Cs**

117 M A Formankiewicz¹, S J Waugh¹, M I Hairol² (¹Anglia Ruskin University, UK; ²Universiti Kebangsaan Malaysia, Malaysia; e-mail: monika.formankiewicz@anglia.ac.uk)

The larger magnitude of contour interaction for visual acuity using contrast-modulated (CM) than luminance-modulated (LM) stimuli, may be useful in the detection of amblyopia (eg Hairol et al, 2010 *Journal of Vision* 10(7), 1332). Performance level at which acuity is taken varies for different paradigms and charts. To investigate whether different termination rules affect the magnitude of contour interaction measured, we analysed psychometric functions for a LM and CM resolution task, with and without flanking bars. Psychometric function slopes were flatter for CM (~4.5) than LM stimuli (~5.0), but this does not contribute to the greater contour interaction reported for CM, than LM stimuli. Slopes for the abutting condition only, were different (flatter) than the isolated condition, especially for LM stimuli. This causes the peak of contour interaction to sometimes occur away from the abutting condition and its magnitude to increase up to 0.1 logMAR (1 line on a chart) with increasing performance level (and size). Different psychometric function slopes for abutting bars only, can affect contour interaction magnitudes reported in research, depending on termination rules. However clinically, where bars are placed some distance away from the target, magnitudes would not likely be affected.

◆ **Effective eye movements training of patients with tunnel vision—a randomized and controlled study**

118 I V Ivanov, A Vollmer, C Gehrlach, A Cordey, N X Nguyen, S Trauzettel-Klosinski (Center for Ophthalmology, Low Vision Clinic and Research Lab, University of Tuebingen, Germany; e-mail: susanne.trauzettel-klosinski@uni-tuebingen.de)

Tunnel vision is a severe peripheral visual field loss condition, impairing mobility. It affects orientation, navigation and eye movement pattern while walking through obstacles in daily-life. We trained patients with tunnel vision caused by retinitis pigmentosa (RP) to extend their eye movements, causing increase in dynamic visual field (VF). Patients were randomly assigned into two training groups: saccadic (experimental) or reading (placebo). Eye positions while walking in real environment were recorded before and after training by Tobii Glasses Eye Tracker. Eye movement pattern was assessed by calculating the sample horizontal and vertical standard deviations (dispersions) of the eye positions. We compared dispersions of patients with reading and saccadic training with a control group of normals. Before and after training, saccadic patients with residual VF > 15° and reading patients did show wider horizontal than vertical dispersions, which were not significantly different from the normals. However, saccadic patients with residual VF < 15° showed equal horizontal and vertical dispersions before training. After training horizontal dispersion significantly increased. We conclude that the specific eye movement training assigned to the RP patients with VF < 15° effectively increased their dynamic VF.

◆ **BOLD evidence linking deficits in early vision to Schizophrenia**

- 119 K Seymour¹, T Stein², L Sanders², I Theophil¹, P Sterzer¹ (¹Charite Universitätsmedizin Berlin, Germany; ²Humboldt Universität and Charite Universitätsmedizin Berlin, Germany; e-mail: kiley_seymour@yahoo.com.au)

It has been proposed that the cognitive deficits associated with schizophrenia can be attributed to an impaired use of contextual information to interpret stimuli. In support of this, recent evidence suggests that some low-level contextual interactions in vision may be weaker in schizophrenia, linking early neural processing to a more intrinsic disturbance of cortical architecture associated with the illness. One of the best-studied examples of contextual influence in vision is that of orientation processing. Here, in schizophrenic patients and healthy age-matched controls, we examine orientation-specific contextual suppression of the BOLD signal in occipital cortex. We find evidence indicating that basic visual processing of contextual information is altered in schizophrenia, supporting recent suggestions that early sensory disturbances may underlie the cognitive deficits commonly associated with the disorder.

◆ **Population receptive field mapping in patients with schizophrenia**

- 120 E J Anderson, M S Tibber, D S Schwarzkopf, G Rees, S C Dakin (UCL, UK; e-mail: e.anderson@ucl.ac.uk)

Schizophrenia (SZ) is a disorder characterised not only by high-level cognitive dysfunction, but also by low-level changes in visual perception. In particular, patients with SZ are less susceptible to the influence of visual context, resulting in weak effects on a range of contextual visual illusions, including size, contrast, motion and orientation judgments. In healthy observers, the strength of these illusions anti-correlates with the surface area of V1 ie individuals with a large V1 experience weaker illusions. We therefore hypothesised that those patients with SZ who demonstrate reduced susceptibility to contextual effects will have larger V1 surface area, smaller population receptive field (pRF) sizes and increased cortical magnification factor (CMF). We used high-field fMRI to calculate pRF sizes, CMF and the surface area of V1 to V3 in 20 patients with SZ and 20 healthy controls. As predicted, patients with SZ had consistently smaller pRF sizes in V1- V3, compared to healthy controls. These functional differences in the architecture of the visual cortex in patients with SZ may play a causal role in the observed changes to visual perception.

◆ **Patterns of fMRI visual cortex activation in patients with hemianopia**

- 121 R Millington¹, C Yasuda², G Beltramini², P Jindahra³, J Barbur⁴, G Plant⁴, C Kennard⁵, F Cendes², H Bridge¹ (¹FMRIB Centre, University of Oxford, UK; ²Dept of Neurology, University of Campinas, Brazil; ³The National Hospital for Neurology and Neurosurgery, UK; ⁴Applied Vision Research Centre, City University, UK; ⁵Nuffield Dept of Clinical Neurosciences, University of Oxford, UK; e-mail: rebecca.millington@new.ox.ac.uk)

Homonymous field deficits reflect damage to the post-chiasmal visual pathway. Damage to different locations along this pathway can cause differences in visual field loss and varying access to subcortical nuclei. It is of interest to establish whether variability in residual visual function is related to the location of the lesion. We used fMRI to examine activity in striate cortex (V1) and the motion area (V5/MT) in fourteen patients with damage to the optic tract, lateral geniculate nucleus, optic radiation, or occipital cortex. Moving dot stimuli were employed to stimulate the affected hemifield, unaffected hemifield or centrally spanning both hemifields. All hemianopia patients showed reduced activity in the affected hemisphere, regardless of lesion location. Ten patients showed little or no occipital activation to stimuli presented in the blind hemifield. Quadrantanopia patients (n= 3) showed no V1 activity to stimuli presented in the blind quadrant, but did exhibit activation in the affected hemisphere when the stimulus crossed the horizontal meridian. Interestingly, some patients showed unexpected activation patterns, such as similar contralesional V1 activation to stimuli presented in either hemifield. These unusual responses may reflect structural reorganisation of the visual pathways since they do not appear to be related to lesion age or location.

◆ **Multisensory cortical integration in patients with hereditary cone dystrophy: a fMRI and**

DTI study

- 122 S Crespi¹, S Bianchi Marzoli², G Triolo³, F Bandello¹, M C Morrone⁴, A Falini¹ (¹Università Vita-Salute San Raffaele, Milano, Italy; ²Istituto Auxologico Italiano, Italy; ³Istituto Scientifico San Raffaele, Milano, Italy; ⁴Università degli Studi di Pisa, Italy; e-mail: giacinto.triolo@libero.it)

Hereditary cone dystrophies (HCD) determine deprivation of normal visual input to the portion of V1 representing the macula. In congenitally blind subjects, functional MRI studies (fMRI) demonstrated

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that the “deafferented” V1 responds to stimuli of different sensory modalities. We aim to understand if a similar reorganization is present in HCD. In 7 HCD patients and 7 normal subjects we measured fMRI cortical response to audio, visual and audio-visual stimuli and used MR Diffusion Tensor Imaging (DTI) to quantify the integrity of the optic radiations and the connections between V1 and A1. The ON stimuli were expanding-contracting visual flow motion (extending 3 deg within the scotoma), auditory looming-receding flow motion, or a combination of the two. The OFF stimulus was a grey background with peripheral square stimulus to help fixation. Although in normal blind folded subjects no response to sound was ever observed in V1/V2, in HCD patients acoustic stimuli activated deafferented V1. DTI results revealed no differences in white matter microstructure between patients and controls along the Inferior Longitudinal Fasciculus or the Inferior fronto-occipital fasciculus. This data suggests a cortical reorganization of function in deafferented V1, despite the late onset of the disease and the lack of major anatomical changes.

◆ **Global motion coherence performance after extended blindness: stretching the window**

123 G Chatterjee, A Kalia, G Tapan, P Swami, P Sinha (Massachusetts Institute of Technology, USA; e-mail: drgarga2@gmail.com)

Global motion perception is an important building block of visual development. Is this ability available for use in individuals who gain sight late in life? Examples of global motion assessment after recovery from extended blindness are scanty (Ellemberg et al, 2002; Fine et al, 2003). As a part of Project Prakash, we studied 8 subjects who were blind for the first 8 to 17 years of life because of very-early onset bilateral cataracts. Global motion perception was assessed by measuring coherence thresholds using random dot kinetograms (Newsome and Paré, 1988). The assessments were conducted 4 months to 2 years post cataract removal. All subjects had above chance global motion coherence thresholds with the performance of some subjects approaching near-normal levels. Evidence for even partial acquisition of global motion coherence is significant in that it shows that even extended periods of blindness starting near birth do not entirely preclude the development of this ability. The present data greatly extends the window of very early onset blindness duration after which acquisition or development of global motion coherence sensitivity is possible.

◆ **Prism adaptation in cerebellar patients**

124 K Spang¹, D Timann-Braun², M Glickstein³, M Fahle⁴ (¹Bremen University, Cognium, Germany; ²University of Essen, Neurologische Klinik, Germany; ³University College London, Institute of Cognitive Neuroscience, UK; ⁴Bremen University, Germany; e-mail: kspang@uni-bremen.de)

Eye-hand adaptation to prisms shifting the visual input horizontally is far more complex than meets the eye. Depending on the exact experimental conditions, the felt position of the hand adapts, and/or the perceived position of the eye in the orbit as well as the perceived position of the head relative to the trunk. We tested the textbook wisdom that cerebellar patients lack prism adaptation. 18 patients suffering from unilateral cerebellar lesions due to strokes and 14 students performed ballistic movements towards a visual target with and without prisms shifting the visual input by 170 deg to the left with the hands visible only at the endpoint of the movement. This procedure leads to an adaptation mostly of the visual input (felt eye position relative to trunk). Speed of adaptation and re-adaptation as well as size of both direct and after-effect did not differ between our group of patients and the control group of students! This difference to textbook results may be due to the fact that opposite to previous studies, we did not ask our patients to ignore their pointing errors, a procedure aimed at eliminating cognition-based adaptation. Still, we found a significantly smaller after-effect in the lesioned versus intact side.

◆ **Metamorphopsia and visual acuity**

125 E Wiecek¹, S Dakin¹, P Bex² (¹University College London, USA; ²Massachusetts Eye and Ear Infirmary, USA; e-mail: emilywiecek@gmail.com)

Metamorphopsia (visual distortion) is a common problem for patients with visual impairment, including macular degeneration, macular edema, epiretinal membrane, and amblyopia. Metamorphopsia is currently assessed with Amsler charts and acuity; however, the contribution of distortion to visual acuity loss is unknown. Here we examined the relationship between spatial distortion (both intrinsic and extrinsic) and letter acuity. Four normally-sighted observers and two observers with self-reported metamorphopsia completed a (10AFC) Sloan-letter identification task on six letter sizes undergoing different levels of spatial distortion (applied using a pixel remapping algorithm). Metamorphopsia was confirmed and quantified with a dichoptic pointing task in which observers aligned two stimuli presented separately to either eye. Spatially band-passed filtered noise was used to remap the pixels and varied over six spatial

frequencies and six amplitudes. Performance was modeled using ordinal logistic regression. Letter identification decreased as spatial frequency and magnitude of distortion increased ($p < 0.01$) and letter size decreased ($p < 0.01$). Normally-sighted observers performed significantly better than observers with metamorphopsia. Letter size and an interaction term between magnitude and letter size were significant predictors of performance. This nonlinear relationship means that acuity is an unreliable indicator of visual impairment in the presence of metamorphopsia.

◆ **Effects of different levels of retinal illuminance on grating and letter acuities using luminance- and contrast-modulated stimuli**

126 N Ahmad, S J Waugh, M A Formankiewicz (Anglia Ruskin University, UK; e-mail: norsham.ahmad@anglia.ac.uk)

Letter and grating acuities are degraded with decreasing retinal illuminance for standard luminance stimuli and investigating their interrelationship has proved helpful in understanding normal and amblyopic vision (Levi and Klein, 1982 *Nature* **298** 268–270). Degrading normal spatial vision by using neutral density filters might mimic amblyopia. Grating and letter acuities were measured for luminance (L), luminance-modulated noise (LM) and contrast-modulated noise (CM) Gabors and C stimuli. Observers wore goggles that incorporated a 2.5mm diameter pupil and different neutral density filters resulting in retinal illuminances between ~0.5–500 tds. Grating acuities were degraded with reduced retinal illuminance at a steeper rate for CM stimuli, depending on the noise (slope ~0.4–0.7) than for L and LM stimuli (slope ~0.3). Letter acuities for all stimulus types behaved similarly (~0.4–0.5). A comparison of the effects on gratings versus letters showed approximate equivalence; or greater effects on gratings for CM stimuli were found. For L and LM stimuli, reduced retinal illuminance degrades normal vision in a way similar to that previously found in anisometropic amblyopia. It is unlike the effects found in strabismic amblyopia, where letter acuity is more affected than grating acuity. For most CM stimuli, degraded vision affects grating acuity more than letters.

POSTERS: CROWDING

◆ **Sensitivity to gaze-contingent spatial distortions in freely viewed movies**

127 T Wallis, M Dorr, P Bex (Schepens Eye Research Institute, Dept of Ophthalmology, Harvard Medical School, USA; e-mail: thomas.wallis@schepens.harvard.edu)

Spatial resolution outside the fovea is progressively limited, and peripheral vision suffers from crowding, yet our subjective experience of the world is of uniform resolution. It has been suggested that this is due to learned representations of the statistical regularities in natural scenes. To probe these representations, we examined sensitivity to localised spatial distortions within which each pixel was shifted based on a bandpass noise process, preserving lower-order statistics but perturbing higher-order statistics. Four observers freely watched 8 hours of a blu-ray TV series on a low-latency gaze-contingent display. Distortions were presented at random intervals at one of four locations centred 4 degrees from the fovea and were spatiotemporally windowed in a Gaussian envelope (SD 1 degree and 80 ms). We varied the amplitude as well as the wavelength (0.25, 1, and 4 cpd) of the distortion. Observers each completed ~8,000 trials and were less sensitive to high- than to medium- and low-frequency distortions. We use reverse correlation to estimate the relationship between local image statistics at the target location and performance, both for retinotopic and spatiotopic statistics around the time of freely made saccades.

◆ **Perceived numerosity in the peripheral visual field**

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Humans are able to estimate the number of elements in a cluster. Numerosity has been proposed as a basic visual feature given that it is susceptible to adaptation (Burr and Ross, 2008 *Current Biology* **18** 425–428) and numerosity detectors have been shown to emerge in a neural network coding sensory data (Stoianov, Zorzi, 2012 *Nature Neuroscience* 194–196). The appearance of basic visual features, in particular spatial frequency, is distorted in the periphery of the visual field (Thorpe et al, 1987 *Journal of the Optical Society of America* **4** 1606–1611). Here we explored whether the perceived numerosity of peripheral elements is distorted. We presented eight observers with a reference central crowd of dots ($N = 30, 60$, or 90), forcing them to fixate its center using a gaze-contingent display. A test crowd of dots with variable numerosity was placed at 12 or 16 degrees of eccentricity. Observers indicated the more numerous crowd. PSE analysis showed that the numerosity of the clusters was underestimated by 7.5% at 12° and

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17.6% at 16°. Our results are consistent with the idea that crowding limits the access of the numerosity detectors to some of the elements.

◆ **A Bayesian account of context-induced orientation illusions**

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In classical tilt illusion, perceived orientation of a target object is repulsed from the orientation of surrounding context. Usually, it has been explained by an interaction between neural populations sensitive to different orientations. My earlier study (Poder 2009 *Perception* **38** ECVP Supplement, 179) with crowded orientation stimuli showed a strong assimilation bias at about the same target-surround differences, opposite to the classical tilt illusion. In this study, I tried to clarify the mechanisms of these opposite biases. I presented the same stimuli (a central target and six surrounding Gabor patches) in central and peripheral locations of the visual field. For central presentation, stimuli with either high or low contrast were used. Orientation difference between the target and surround was varied. Absolute orientation was random. After the brief exposure, observers had to reproduce the perceived target orientation (by rotating a response patch). Both eccentricity and contrast manipulations indicate that reduced visibility of the target orientation increases the range of target-surround differences where assimilation bias is observed. It appears that perceived homogeneity vs target pop-out determines the nature of illusion. A Bayesian model with competing (context-dependent) priors was built that produces qualitatively similar results. [Supported by Estonian Ministry of Education, project SF0180027s12.]

◆ **How recurrent dynamics explain crowding**

130 A Clarke¹, M Herzog² (¹École Polytechnique Fédérale de Lausanne, Switzerland; ²EPFL, Switzerland; e-mail: aaron.clarke@epfl.ch)

In crowding, flankers impair target perception. For example, Vernier offset discrimination deteriorates when the Vernier is flanked by parallel lines. Pooling models explain crowding by averaging neural activity over both Vernier and flankers. Recently, however, it was shown that adding flankers can reduce crowding almost to baseline levels, contrary to predictions of pooling models. Here, we show that a Wilson-Cowan type model can explain both classical, local and recent, global aspects of crowding. The key feature of the model is spread of inhibitory neural activity across similar elements. For example, crowding strength decreases with more long flankers because these similar, long flankers inhibit each other dynamically and, thus, reduce inhibition on the dissimilar Vernier. Since the Vernier is similar to the equal-length flankers, it is inhibited. For this reason, and in accordance with psychophysical data, crowding does not vary with the number of equal-length flankers.

◆ **Does flanker identity affect perceived target position in crowding?**

131 F Yildirim, F W Cornelissen (University Medical Center Groningen, Netherlands; e-mail: f.w.cornelissen@umcg.nl)

A visual target is more difficult to recognize when other, similar, objects surround it. This is known as crowding. A recent model suggests that crowding is due to a combination of spatial and identity uncertainty (Van den Berg et al, 2012 *Journal Vision*). Here, we tested whether the identity of the flanking objects could also affect the perceived spatial position of a target, potentially adding to the spatial uncertainty. In our experiment, targets and flankers were presented in the peripheral visual field, and consisted of gabor patches. Two flankers that varied in orientation surrounded the target. An isolated patch with a fixed orientation was presented on the other side of fixation and served as a reference. Observers indicated whether the target or reference was closer to fixation. Pre-tests eliminated possible confounds. Orientation of an isolated target stimulus did not affect performance. As expected, neither did flankers presented outside the critical distance of crowding. In our main experiment, we found that flankers well within the critical spacing affected performance, and that flanker orientation modulated performance. We conclude that flanker identity affects the perceived position of the target.

◆ **Lesser crowding of letters generalizes across parafovea but not to vertical string orientation**

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Contrary to the conventional bottom-up view (Pelli and Tillman, 2008 *Nature Neuroscience* **11**(10) 1129–1135), crowding can be dependent on object type. Namely, letters are shown to be less prone to crowding than some other symbols (Grainger et al, 2010 *Journal of Experimental Psychology: Human*

Perception and Performance **36**(3), 673–688). This effect was attributed to perceptual learning. Using 2-AFC letter identification task, we examined whether the described effect generalizes to different parafoveal locations and to different string orientation. Results of experiment 1 showed that letters are indeed less crowded than symbols at all tested locations in parafovea (left, right, above and below the fixation). Importantly, however, described letter advantage was only observed when the stimuli were shown in horizontal orientations. In vertical orientation there was no difference among letters and symbols. The effects of radial-tangential anisotropy were equal for both stimulus types. Results of experiment 2 showed that radial-tangential anisotropy was canceled out when stimuli were presented at four diagonal positions in parafovea. This manipulation did not affect the selective advantage of the horizontally arranged letters in comparison to vertical letter strings and to symbols in either orientation. [This research was supported by the Ministry of Education and Science of the Republic of Serbia (grant number: 179033).]

◆ **Texture segmentation: Crowding can occur in detection tasks**

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In visual crowding an irrelevant visual object can impair target recognition, even when it appears several degrees away from the target. Until now it is commonly agreed that crowding occurs only in target identification or target discrimination tasks, but not in target detection (eg Pelli et al, 2004 *Journal of Vision* **(12)**4 1136–1169). In a texture segmentation study, we investigated whether an irrelevant texture irregularity can impair target detection within a critical distance around the target. Data were also tested for anisotropic masking, which is considered as a 'litmus test' of crowding (Petrov et al, 2007 *Journal of Vision* **(2)**7 1–9). Furthermore it was investigated whether critical distances and anisotropic masking can be found not only when target and irrelevant irregularity are from the identical feature dimension, but also when they are from different feature dimensions. Results show that critical distances and anisotropic masking can be observed in a detection task. These two characteristics of crowding were found when the target and the irrelevant irregularity were from the identical feature dimension, as well as when they were from different feature dimensions.

POSTERS: ENCODING AND DECODING

◆ **Tracking eye movements while encoding faces**

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While many studies have shown that a middle band of spatial frequencies (SF) is most useful for face recognition, others have pointed out that the most informative SF ranges vary depending on location on the face. In this study, we examined similar issues by measuring 32 subjects' eye movements during the encoding phase of an old/new face recognition task. Stimuli were 16 faces filtered to preserve 11 SF bands across the spectrum, plus an unfiltered baseline condition. Twelve areas of interest (AOIs) were defined for each face, and total fixation time was analyzed across AOI and SF. Results show that low SFs elicited more fixations on medial AOIs such as nose, forehead and chin. This may indicate a tendency towards holistic processing, whereby fixation on these features represents an attempt to take in the entire face. In contrast, high SFs elicited more fixations on inner features, such as eyes and mouth, suggesting greater featural processing. Our results are compatible with previous work suggesting that low and high SFs respectively support holistic and featural processing. The advantage of middle SFs may arise because these allow for sufficient analysis of both holistic and featural aspects of face processing.

◆ **The effects of background noise on microsaccades generation in humans**

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Microsaccades are miniature saccades occurring once or twice per second during visual fixation. While microsaccades and saccades share similarities at the oculomotor level (same kinematic properties, eg duration, specific relationship between peak velocity and amplitude...), the functional roles of microsaccades are still debated. In this study, we examined specifically the possibility that the "microsaccadic activity" is affected by the type of background across which fixation is maintained. Using a forced choice-task paradigm adapted from Rucci and colleagues (2007 *Nature* **447**(14) 851–855), we found that the performance of subjects in discriminating the tilt of high-spatial-frequency stimuli (textured ellipses) was significantly better in the dynamic condition compared to the static condition,

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on average (but this was not systematic for each of the 30 tested subjects). This was associated with a systematic and significant effect of the background noise on the microsaccade rate: microsaccades occurred more frequently (by up to 25%) in the static condition. Our experimental findings served to integrate the signal-to-noise ratio (between the stimulus and the visual environment) as a critical parameter in a simple model of microsaccade generator. Taken together, our experimental findings and our preliminary computational predictions provided new insights into the potential roles of microsaccades in visual perception.

◆ **Representation of component motion in V1 predicts perceptual thresholds for pattern motion**

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We study the perceptual representation and model the neural representation of pattern motion. Lacking quantitative characterizations of neuronal responsiveness in area MT, we derive theoretical predictions from the responsiveness of motion-selective neurons in area V1, which are comparatively well characterized. Given a quantitative model of responsiveness (tuning and variability) to component motion, we have previously predicted the responsiveness (tuning and variability) to pattern motion, assuming statistically efficient integration of Fisher information (2011, *Perception* **40** ECVF Supplement). These theoretical results predict that sensitivity to speed and direction of pattern motion should vary with the constitutive component motions. We now report psychophysical threshold measurements that quantitatively confirm these predictions. Specifically, 5 Observers viewed composite arrays of two types of component motion wavelets. Thresholds for direction of pattern motion decrease, whereas thresholds for speed of pattern motion increase, with the angle between component wavelets. In conclusion, we can predict neural responsiveness at the level of pattern motion (presumably in area MT) from psychophysical measurements and from neural responsiveness at the level of component motion (area V1).

◆ **The role of neural noise in perceiving looming objects and eluding predators**

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M Keil (University of Barcelona, Spain; e-mail: matskeil@ub.edu)

For many organisms, escaping from predators and avoiding collisions is of paramount importance to shun fatality. Looming-sensitive neurons reveal similar properties across species. The ETA-function describes one class of such neurons, and asserts a multiplicative interaction and an exponential nonlinearity (Gabbiani et al, 2002 *Nature* **420** 320–324). Recently, I showed that a new function ("PSI") could implement ETA in a biophysically plausible fashion without multiplication (MS Keil, NIPS 2012). Instead of ETA's exponential nonlinearity, PSI incorporates a power law, that also agrees better with neurophysiological properties of the locust lobula giant movement detector (LGMD). This neuron receives a large number of inputs, where noise levels increase from the photoreceptors to the LGMD (Jones and Gabbiani, 2012 *Journal of Neuroscience* **107** 1067–1079). Provided that some of these input channels have threshold properties, and assuming independent noise in each channel, a power law emerges as a result from pooling. As PSI represents a biophysical implementation of ETA, the groundbreaking idea is that no nonlinearities besides thresholding are necessary for explaining the properties of collision-sensitive neurons. I thus will present corresponding simulation results with a modified PSI model and discuss the implications.

◆ **Encoding space in time during active fixation**

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X Kuang¹, M Poletti¹, J D Victor², M Rucci¹ (¹Boston University, USA; ²Weill Cornell Medical College, USA; e-mail: mrucci@bu.edu)

It has long been known that humans and other species continually perform microscopic eye movements, even when attending to a single point. However, the impact of these movements on retinal stimulation and on the neural encoding of visual information remains unclear. Here, we examine the spatiotemporal stimulus on the retina of human observers while they freely view pictures of natural scenes. We show that the spectral density of the retinal image during normal intersaccadic fixation differs sharply from that of the external scene: whereas low spatial frequencies predominate in natural images, fixational eye movements equalize the power of the retinal image over a wide range of spatial frequencies. This reformatting of the visual input prior to any neural processing attenuates sensitivity to redundant information and enhances responses to luminance discontinuities, outcomes long advocated as fundamental goals of early visual processing. Our results link microscopic eye movements to the characteristics of natural environments and indicate that neural representations are intrinsically sensory-

motor from the very first processing stages. [Supported by NIH EY18363, EY07977 and EY09314, and NSF BCS-1127216.]

◆ **Smothered by the scene: When context interferes with memory for objects**

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How tightly are object representations in our memory bound to scene context? Arbitrary objects, presented in isolation are remembered very well when tested in a subsequent old/new task (Brady et al, 2008 *Proceedings of the National Academy of Sciences of the USA* **105** 12325–14329; $d' = 2.27$ in our data). When we asked observers to memorize the same objects embedded in a scene, but clearly placed in an outlined box, performance dropped ($d' = 1.40$). When observers memorized objects in one scene context and had to make an old/new judgment about those objects and foils presented in new contexts, performance dropped still further ($d' = 0.62$) even though the scene contexts were completely irrelevant to the task. The negative effect of scene context was more pronounced if the scene was present during the encoding phase ($d' = 0.53$) compared to the retrieval phase ($d' = 1.44$). In other circumstances, context information has been shown to facilitate retrieval of object details (Hollingworth, 2006 *Journal of Experimental Psychology: Learn, Memory, and Cognition* **32** 58–69; Hollingworth, 2007 *Journal of Experimental Psychology: Human Perception and Performance* **33** 31–47). Here, however, these findings suggest that scene information is involuntarily encoded with object information in a manner that has a disruptive effect on memory for the object alone, in context, or, especially, in a novel context.

POSTERS: EYE MOVEMENTS

◆ **Probability effects in antisaccade performance**

140 O Johannesson, H M Haraldsson, A Kristjansson (University of Iceland, Iceland;
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Probability manipulations between the left and right visual fields have been reported to influence antisaccade performance of healthy observers such that latencies of antisaccades to low-probability landing points do not result in the widely reported latency cost for antisaccades compared to prosaccades (Liu et al 2010, *Journal of Neurophysiology* **103**(3), 1438–1447). According to this, antisaccade costs are modulated by probabilistic contextual information such as regarding location. This probability effect was observed in a paradigm where the necessity for attentional disengagement from a saccade target was eliminated. We investigated such probability manipulations for horizontal saccades in a number of different antisaccade paradigms, with and without gaps between fixation point and target and with 2 to 4 different target positions. No effects of probability manipulation were found upon latency costs for antisaccades in our paradigms. The latencies observed by Liu et al were considerably longer than those typically seen for antisaccades, which raises the possibility that decision times for saccades were very long because of task difficulty. The disappearance of the antisaccade cost may therefore only apply to very difficult saccade tasks involving a challenging decision stage. Experiments are currently under way in our laboratory to explore this more thoroughly.

◆ **Distribution of gaze points during natural viewing under a wide field-of-view condition**

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Eye tracking data during free viewing of natural scenes with a wide field-of-view (WFOV: 80 degrees) screen were collected using our newly developed gaze-tracking system, and the distribution of the data was compared with that acquired under a relatively narrow FOV (NFOV: 40 degrees) condition. The eye tracking system achieved 80 degrees in horizontal FOV and around two degrees in estimation error in almost measurable area without adding constraints to the subjects' viewing. We widened its measurable area by utilizing five eye-sensing cameras. The mean values of the entropy within each scene (5–30 s) were derived from analysis applying a Gaussian mixture model to the collected data frame by frame, and these were compared for the two conditions. The numbers of salient areas in each frame were also extracted with a saliency model and blob analysis. We found that the mean entropy under the WFOV condition was considerably higher than that under NFOV for the scenes with moderate (5–15) salient regions. On the other hand, converse results were obtained for scenes with fewer or more salient areas. This suggests that the number of salient areas is a critical feature to differentiate viewers' eye movements under variant FOV conditions.

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◆ **Importance of the position of face presentation for gaze and perceptual biases study**

142 H Samson, N Fiori, K Doré-Mazars, C Lemoine, D Vergilino-Perez (Vision Action Cognition Université Paris Descartes, France; e-mail: dorine.vergilino-perez@parisdescartes.fr)

Previous studies demonstrated a left perceptual bias while looking at faces, observers using mainly information from the left side of a face to make a judgment task. Such a bias is consistent with right hemisphere dominance for face processing and has been sometimes linked to a left gaze bias, ie more and longer fixations on the left side of the face. Here, in several experiments we recorded eye-movements during a gender judgment task, using normal and chimeric faces presented at the top, bottom, left or right relative to the central fixation point or at the center. Participants performed the judgment task by remaining fixated on the fixation point or after executing one, two or three saccades. Overall, we observed that one saccade was sufficient to make a judgment task: Percentage of correct responses did not improve with further saccades. The left perceptual bias was function of the number of saccades that were performed, while the gaze bias was function of face position. No apparent link between gaze and perceptual biases was found in any experiments, meaning that a perceptual bias was not systematically coupled to saccades made toward the side of faces which was used to perform the gender judgment.

◆ **Dynamic characteristics of saccadic eye movements are affected by ocular size**

143 M Alhazmi, L S Gray, D Seidel (Glasgow Caledonian University, UK; e-mail: mohammed.alhazmi@gnu.ac.uk)

Purpose: To determine the effect of eye size and ocular rigidity upon the characteristics of saccadic eye movements (SEM). Methods: 33 subjects (mean age 23.52 ± 5.11 years) participated with informed consent. Axial length was measured using partial coherence interferometry (IOLMaster, Carl Zeiss, UK) and ranged from 21.3mm to 27.7mm. Ocular rigidity coefficients were determined using Schiotz tonometry and ranged from 0.013 mm^{-3} to 0.019 mm^{-3} . SEM were stimulated randomly up to 40 degrees right and left, in 10 degree steps using high contrast targets presented upon a widescreen monitor at 40cm viewing distance. Eye movements were recorded continuously at a sampling rate of 60Hz using the Viewpoint video-eyetracker (Arrington Research, USA). Subjects were grouped equally by axial length into short ($22.63 \pm 0.66 \text{ mm}$), medium ($24.10 \pm 0.41 \text{ mm}$) and long ($25.90 \pm 0.10 \text{ mm}$) groups. Results: Axial length was significantly negatively correlated with ocular rigidity ($r^2 = 0.78$, $p < 0.001$). Peak velocity was significantly faster for the short axial length group ($F = 20.825$, $df = 2, 263$, $p < 0.001$), although initial SEM accuracy was significantly worse ($F = 2.954$, $df = 2, 263$, $p = 0.048$). Peak velocity was significantly greater with increasing stimulus magnitude ($F = 741.759$, $df = 3, 263$, $p < 0.001$) and was also significantly greater for abductive movements ($F = 3.940$, $df = 1, 263$, $p = 0.048$). Conclusion: Eyes with short axial length and higher ocular rigidity generate significantly higher velocities of SEM.

◆ **Visual and virtual pursuit in movies: The oculomotor and memorial consequences**

144 Y Hirose, B W Tatler, A Kennedy (University of Dundee, UK; e-mail: y.hirose@dundee.ac.uk)

The spatial coding of object position in movies is relatively poor compared to the processing of position information in static scenes or natural behaviour. During movie sequence that tracks an actor's progress, the background is in relative motion whereas the actor remains near-stationary. This virtual pursuit is in marked contrast to the situation when pursuing a moving target where the background is stationary but the target is in relative motion (visual pursuit). Is virtual pursuit (the phenomenal experience of pursuit without the concomitant eye movements) responsible for poor position memory in movies? Manipulating both the camera movement (static/tracking) and actor presence (present/absent), we compared the oculomotor and memorial influences of viewing movies with visual and virtual pursuit. The results showed that camera movement influenced fixation allocation on objects, whereas actor presence influenced both fixation allocation and durations. In contrast, object position and identity memory were explained by total fixation durations irrespective of camera movement or actor presence, while memory for colour was influenced by actor presence. The results indicate that camera movement and actor presence have oculomotor consequences and the latter also affects memory for colour, but these two factors do not influence information extraction for object position and identity.

◆ **Static gaze direction detection in children with autism: a developmental perspective**

145 R Fadda¹, G Doneddu², S Congiu², A Salvago², G Frigo², T Striano³ (¹Dept of Psychology, University of Sheffield, UK; ²Center for Pervasive Developmental Disorders, AOB, Italy; ³Hunter College, New York, USA; e-mail: tstriano@hunter.cuny.edu)

Gaze direction detection in Autism Spectrum Disorders (ASDs) is controversial. Accurate gaze judgment appears problematic for individuals with ASDs (ie Webster and Potter, 2008 *Journal of Autism and*

Developmental Disorders **38**(6), 1184–1186), while the basic geometric understanding of gaze direction seems to be preserved (Sweetenham et al, 2003 *Philosophical Transactions of the Royal Society, Series B* **358** 325–334). However, it is not clear whether possible impairments in ASDs might correspond to a possibly immature pattern of visual attention or to a specific deficit. Using eye tracking technology, we investigated gaze direction detection in children with ASDs, in comparison with three groups of typically developing individuals (TD): 20 chronological age-matched TD children, 20 TD toddlers and 20 TD adults. The results showed that ASDs were as accurate as controls across ages in gaze direction detection ($F_{3,76} = 3.006$; $p = 0.035$). However, they focused significantly less upon the eyes, which is the most relevant region of the picture for task completion, and they did not show any preference for the gaze target overall ($F_{6,152} = 5.02$, $p < 0.05$). Their pattern of attention was different from TD children and adults but similar to that of TD toddlers and therefore it could be considered as a result of an immature pattern of visual attention.

◆ **Spatial localization of sounds under free-field and dichotic presentation: The role of eye movements**

146 S Targher¹, A Fracasso², M Zampini³, F Pavani³ (¹Center for Mind and Brain Sciences, University of Trento, Italy; ²Center for Mind and Brain Sciences, University of Trento; Dept of Psychology, Utrecht University, The Netherlands, Italy; ³Center for Mind and Brain Sciences, University of Trento; Dept of Cognitive and Education Sciences, University of Trento, Italy; e-mail: stefano.targher@gmail.com)

In a previous study, Pavani and coworkers (Pavani et al, 2008 *Experimental Brain Research* **189** 435–449) found interfering effects of an eye movement intervening between two consecutive free field sounds, when participants were asked to compare relative spatial position of the sounds (same/different task). By contrast, Kopinska and Harris (Kopinska and Harris, 2003 *Canadian Journal of Experimental Psychology* **57** 23–37) found no eye movement interference, using dichotic sounds delivered through headphones in a task in which participants had to indicate (ie, reposition) the remembered location of a sound after the intervening eye movement. Free field sounds appear in a visible external space, whereas intracranial sounds do not. Here we adopted the paradigm by Pavani et al (2008) to examine the impact of eye movement on auditory spatial cognition when sounds are delivered across blocks either free field or intracranially. Although a significant eye movement effect emerged regardless of sound presentation, the spatial interaction between eye movement direction and auditory change direction depended on whether sounds were free field or intracranial. This indicates different interactions between spatial coding of eye movement and sounds, as a function of whether the sounds appeared in a visible external space or not.

◆ **Comparing eye movements during impression judgment of faces in different personality traits: analysis of fixation locations and durations**

147 N Nakamura¹, A Maruyama¹, Y Inaba¹, H Ishi², J Gyoba³, S Akamatsu¹ (¹Hosei University, Japan; ²Sendai National College of Technology, Japan; ³Tohoku University, Japan; e-mail: yiu57933@nifty.com)

We intentionally manipulated the attributes and social impressions evoked by facial images based on a statistical face model (Kobayashi et al, 2004 *Proceedings of the International Conference of Automatic Face and Gesture Recognition* pp 711–716; Walker and Vetter, 2009 *Journal of Vision* **9**(11) 12 1–13). However, manipulation remains unresolved of the parameters that dominantly contribute to the local features of facial appearance, which is specifically salient in personality traits. To clarify this issue, we investigated whether different features are gazed at while making impression judgments using synthesized face images generated by a statistical model as stimuli. Pairs of synthesized face images, both of which were generated by a statistical model of faces with parameters indicating different salience of a given personality trait (ie, seniority, proficiency, etc), were sequentially presented at normalized positions. For each pair of faces, subjects decided which one was more extreme with respect to the trait in question, while their eye movements were measured by a rapid eye-movement measurement system called EyeLink-C. The eye-movement results were represented in 2D histograms to indicate the spatial distribution of the cumulative duration of the gaze at each fixation point; positions corresponding to the mode of each histogram were analyzed by 2-way ANOVA (Nakamura et al, 2011 *Perception* **40** ECVS Supplement 113). The results suggest that attention is drawn to different features in impression judgments.

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◆ **Sarkozy: left or right? How early can we choose?**

148 M A Mathey, G Besson, G Barragan-Jason, P Garderes, E J Barbeau, S J Thorpe (CNRS CERCO UMR 5549, France; e-mail: marie.mathey@gmail.com)

When a face and a vehicle are flashed left and right of fixation, reliable saccades to the face can be triggered from 100–110 ms (Crouzet et al, 2010 *Journal of Vision*). But can subjects make selective saccades that depend on face identity? Using a manual go/no-go paradigm, our lab has already shown that subjects can detect photographs of Nicolas Sarkozy, with an accuracy of $94.6 \pm 3.0\%$, mean RTs of 364 ± 20 ms and the fastest reliable responses occurring as early as 260 ms (Besson et al, 2011 *Perception* 40ECP Supplement). Here, we used the same material in a saccadic choice task. On each trial a photograph of Nicolas Sarkozy was paired with a photograph of another male face with roughly the same age and appearance. Over the complete set, the images were matched for pose and expression. With the saccade task, accuracy was lower, but still way above chance (range 60–75%). Above all, the responses were very fast, (median RT <190ms and minRT <140 ms). These results imply that information about identity can impact behaviour much faster than had previously been suspected. How such feat can be achieved is currently under investigation.

◆ **Saccadic mislocalization: related to eye movement amplitude or visual target location?**

149 M Matziridi, J B J Smeets, E Brenner (Faculty of Human Movement Sciences, VU University Amsterdam, Netherlands; e-mail: mmatziridi@yahoo.gr)

A stimulus that is flashed around the time of a saccade tends to be mislocalized in the direction of the saccade target. Our question is whether the mislocalization is towards the visual target location or towards the gaze position at the end of the saccade. We separated the two with a visual illusion that influences the perceived distance to the target. We asked participants to make horizontal saccades from the left to the right end of the shaft of a Müller-Lyer figure. Around the time of the saccade, we flashed a bar at one of five possible positions. As expected, participants made shorter saccades for the fins-in (<—>) configuration than for the fins-out (>—<) configuration of the figure. The illusion also influenced the mislocalization pattern, with flashes presented on the fins-out configuration being perceived beyond flashes presented on the fins-in configuration. During the saccade, the effect of the illusion on the perceived location of the flash was similar to its effect on saccade amplitude (~22%). We conclude that the mislocalization is related to the eye movement amplitude rather than to the visual target location.

◆ **The effect of the Müller-Lyer illusion on reflexive, delayed, and memory-guided saccades**

150 A J de Brouwer¹, E Brenner¹, W P Medendorp², J B Smeets¹ (¹VU University Amsterdam, Netherlands; ²Radboud University Nijmegen, Netherlands; e-mail: a.j.de.brouwer@vu.nl)

The amplitude of saccadic eye movements is affected by size illusions such as the Müller-Lyer illusion. The magnitude of the effect of the Müller-Lyer illusion on saccades varies largely between studies (2.5–28.7%; Bruno et al, 2010 *Vision Research* 50 2671–2682). Our goal is to further clarify this variability by testing the influence of a delay on the effect of the Müller-Lyer illusion. According to the “two visual systems hypothesis” (Milner and Goodale, 1995 *The Visual Brain in Action* Oxford, Oxford University Press), responses to memorized target positions rely on a perceptual representation coming from the ventral ‘perception’ pathway, which is affected by visual illusions. Reflexive actions depend on the dorsal ‘action’ pathway that does not have access to this perceptual representation. The proposed distinction between perception and action therefore implies that while reflexive actions are (largely) immune to visual illusions, memory-guided responses are influenced by illusions. In the present study, subjects performed two reflexive saccade tasks (with and without a gap) and two delayed saccade tasks (delayed and memory-guided responses) with the Müller-Lyer illusion. Contrary to the prediction of the two visual systems hypothesis, the effect of the illusion was not the smallest for reflexive responses.

◆ **Dynamical integration of retinal and extra-retinal signals for smooth pursuit eye movements: a two-stage Bayesian model**

151 A Montagnini, A Bogadhi, G Masson (INT, CNRS and Aix-Marseille University, France; e-mail: Anna.Montagnini@incm.cnrs-mrs.fr)

Smooth pursuit eye movements allow us to precisely track a moving target with our gaze. These movements are strongly based on the sensory estimation of target velocity. However, extra-retinal signals, like memory and motion predictability, play an important role as well. Therefore smooth pursuit recordings are considered to be a faithful dynamic readout of motion processing but also to reflect higher-level motion-related information. Building up on previous theoretical and experimental work

on dynamic motion integration and smooth pursuit with ambiguous motion cues (Bogadhi et al, 2011, *Vision Research* **51**867), we propose a two-stage hierarchical recurrent Bayesian model where retinal and extra-retinal signals are dynamically weighted and combined to compute the visuomotor drive and the corresponding tracking dynamics. Importantly, the weights can be expressed as a function of the variance of the sensory input. This model reproduces many experimental observations on smooth pursuit, including the transient oculomotor bias induced by the aperture problem, the tracking behavior during early and late target blanking and the effect of motion predictability on smooth pursuit. In summary, this model provides a general and powerful theoretical framework to understand how different signals (eg retinal and extra-retinal) are dynamically combined to adaptively control our actions.

◆ **Saccade targeting of spatially extended objects: A Bayesian model**

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Visual perception in scene viewing, visual search, or reading is based on saccadic selection of spatially extended objects or patches from the environment for foveal analysis. Saccade planning, however, requires the computation of a localized target position. For example, word centers are the functional target locations within words during reading. An open problem is how readers transform the distributed spatial information into a localized target position for a saccade. Recently, Engbert and Krügel (2010 *Psychological Science* **21**(3), 366–371) presented a Bayesian model for optimal saccade planning during reading. The model assumes that readers apply an efficient strategy for the computation of the center of target words. Here we present an extended Bayesian model that includes the probabilistic computation of the word center. Using this example from saccade generation in reading, we analyze the general problem of how two visual cues (ie, word boundaries in reading) can be used to derive optimal estimates of the center of spatially extended targets. We demonstrate that our Bayesian model is compatible with well-established oculomotor effects. We expect that the model might help to explain saccade planning across a broad range of tasks from scene perception to visual search.

◆ **A simulation study of retinal enhancement effects caused by fixation eye movements**

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In this study, we performed simulation experiments using a mathematical model of the retina to evaluate the effects of fixation eye movements on the peripheral retina. Recent studies indicate that drifts and tremor enhance particular spatial frequency components (Rucci et al, 2007 *Nature* **447** 852–855), and microsaccades emphasize contrast differences present in the visual stimuli (Donner and Hemila, 2007 *Vision Research* **47** 1166–1177). However, the effects of fixation eye movements on the retina, especially on the peripheral retina, are not well understood. The proposed model of the retina considers the distribution function of cone cells, and reproduces the increasing size of the peripheral receptive fields of ganglion cells, based on the mathematical model of the retinal network (Hennig and Worgatter, 2007 *Frontiers Comp Neuroscience* **11**–12). The simulation results showed that drifts and tremor enhanced the responses of ganglion cells for high spatial frequency input, and microsaccades enhanced the responses for low spatial frequency input. These trends were more prominent for the M-type ganglion cells at some distance from the fovea. Furthermore, the simulation suggested that fixation eye movements might generate synchronous fluctuation in the responses of ganglion cells.

◆ **Computational mechanisms of visual stability**

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Cells in many visual areas are retinotopically organized and thus shift with the eyes, posing the question of how we construct our subjective experience of a stable world. While predictive remapping (Duhamel et al, 1992 *Science* **255** 90–92) and the corollary discharge (CD) to move the eyes (Sommer and Wurtz, 2006 *Nature* **444** 374–377) have been proposed to provide a potential solution, there exists no clear theory let alone a computational model of how CD and predictive remapping contribute. Based on a recent model of area LIP (Ziesche and Hamker, 2011 *Journal of Neuroscience* **31** 17392–17405) that focused on spatial mislocalization of brief flashes in total darkness, we show that predictive remapping emerges within a model of coordinate transformation by means of the interaction of feedback and CD. Moreover, we demonstrate the influence of predictive remapping on visual stability as objectified by a suppression of saccadic displacement task (Deubel et al, 1996 *Vision Research* **36** 985–996) using the same model. Remapping introduces a feedback loop which stabilizes perisaccadic activity and thus

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leads to the typical increase in displacement detection threshold, thereby preventing misperceptions about stimulus displacements which might otherwise arise from motor errors in the saccade execution.

◆ **Motion direction integration following the onset of multistable stimuli (I): dynamic shifts in both perception and eye movements depend on signal strength**

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We used an obliquely oriented moving luminance grating within a square aperture as a stimulus. We probed how the aperture problem (determining direction of a contour within an aperture) is solved following onset. It is perceived to move in horizontally (H), diagonally (D) or vertically (V), shifting perception during extended presentation. The initial percept (D) leads to two competing “stable” solutions H and V from the orthogonal 2D cues around the edges. During brief stimulus presentations of 200–500ms, participants reported perceived direction (H, D or V) in a 3-alternative forced choice task while eye movements were recorded. As expected when solving the aperture problem, integration took time: reported direction is predominantly 1D (D) at 200 ms, shifting to 2D (H/V) by 500 ms. Eye direction traces converge to an average direction (H, D or V) that corresponds to participant decisions. The latency of this separation of averaged traces depends on input signal strength parameters like contrast. The relationship between input signal, distributions of perceived direction and forced choice decision thresholds are well described by a neural fields model in our companion abstract (II). The onset dynamics of multistable direction representation are demonstrated to be well studied by ocular following eye movements.

◆ **Perceived motion blur and spatial-interval acuity during smooth pursuit eye movements and fixation**

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Retinal image motion during smooth pursuit eye movements results in a smaller extent of perceived motion blur than when similar image motion occurs during steady fixation (eg, Bedell and Lott, 1996 *Current Biology* 6 1032–1034). We asked if this reduction of perceived motion blur during pursuit influences spatial-interval acuity. Observers pursued a target moving horizontally at 4 or 8 deg/s and judged whether the horizontal separation between two physically stationary lines, presented for 167 ms, was larger or smaller than a previously viewed standard. Three different line separations were tested for each pursuit velocity. The observers also made spatial-interval judgments during fixation, for pairs of lines moving horizontally to generate the same distribution of retinal image speeds as those during pursuit. Spatial-interval acuity was better during pursuit than fixation, especially for smaller separations between the lines of the spatial-interval stimulus. The results indicate that the reduction of perceived motion blur during pursuit eye movements is associated with improved visual spatial performance.

◆ **What can eye movements tell us about object recognition in the normal and impaired visual system? The case of integrative agnosia**

157

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In a recent study (Leek et al, 2012 *Journal of Vision* 12 1, 7) we have shown how eye movement patterns may be used to elucidate shape information acquisition mechanisms during object recognition. Here we report some of the first ever evidence examining eye movement patterns during object recognition in visual agnosia. The eye movements of an integrative visual agnosic patient IES, and controls, were recorded during two object recognition tasks: Object naming and novel object recognition memory. Differences in the spatial distributions of IES's fixations, and fixation dwell times, were correlated with recognition performance in object naming. In addition, in both object naming and novel object recognition memory the patient showed abnormal saccade amplitudes with a bias towards shorter saccades. In contrast, the patient showed normal directional biases and sensitivity to low-level visual saliency. It is suggested that this bias towards low amplitude saccades, and the aberrant spatial distribution of fixations in common object naming, reflects a breakdown in the functional link between bottom-up and top-down guidance of eye movements during shape perception.

◆ **Instrumental activities of daily life in age-related macular degeneration**

158 C Delerue¹, M Thibaut¹, T H C Tran², M Boucart¹ (¹Laboratoire de Neurosciences Fonctionnelles et Pathologies, Université Lille Nord de France, France; ²Hôpital Saint Vincent de Paul, Département d'Ophthalmologie, Lille, France; e-mail: celine.b.delerue@wanadoo.fr)

Questionnaires of quality of life indicate that people with age-related macular degeneration (AMD) report difficulties in performing vision-related daily activities, such as reading, writing, cooking... Studies on visual perception in AMD classically use photographs of objects. However, images differ from the natural world in several ways, including task demands and the dimensionality of the display. Our study was designed to assess whether central vision loss affects the execution of natural actions. We recorded eye movements in people with AMD and age-matched normally sighted participants while they accomplished a familiar task (sandwich-making) and an unfamiliar task (model-building). The scenes contained both task-relevant and task-irrelevant objects. Temporal and spatial characteristics of gaze were compared for each group and task. The results show that patients were able to perform both tasks, though patients were slower and less accurate than controls to copy the display model in the unfamiliar task. Patients exhibited longer gaze durations than controls on irrelevant objects in both tasks. They also looked longer at task-relevant objects and needed to manipulate more the objects to identify them. People with AMD exhibit difficulties in natural actions, but they seem to establish compensatory strategies (eg, object manipulations) to accomplish correctly the task.

◆ **Object and scene exploration in people with age-related macular degeneration (AMD)**

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People with lesions of the macula develop a central scotoma and must rely on their peripheral vision. Most studies in people with central field loss have focused on reading which constitutes the main complaint of patients. Some studies have shown impairments in face or object detection or recognition tasks. Little is known about how people with central visual field loss explore realistic images. Could it be that deficits in object perception result from impaired eye movements? We recorded scan paths, saccades and fixations, and naming times in 20 patients with wet AMD (mean acuity 3/10) and 15 age-matched normally sighted controls (mean acuity 9.3/10). Photographs of isolated objects, natural scenes and objects in scenes were centrally displayed for 2 s. The mean angular size was 30 horizontal x 20°. On average accuracy was higher by 23% for controls than for patients. This difference was equivalent for isolated objects and for objects in scenes. The proportion of fixations in regions of interest was lower in people with AMD and their number of saccades was larger than controls. These results suggest that abnormal patterns of exploration might contribute to deficits in object and scene recognition in people with AMD.

◆ **Predicting which objects will be named in an image**

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Object detection and identification are fundamental visual tasks. Einhauser et al (2008 *Journal of Vision* 8(14):18) found that objects are a better predictor of fixation locations than early saliency models. Spain and Perona (2011, IJCV, 91(1)) constructed a model of 'object importance' (defined as the probability of naming an object in a scene) based on object position, size and saliency. For the present study we carried out an eye-tracking experiment involving 24 participants and 132 natural scenes. In each trial, an image was displayed for 5 seconds. Once the image had been removed from the screen, participants had to name as many objects from the scene as possible. In our analysis we examine the extent to which an individual's naming behaviour can be predicted from their scan-path. We test how well scan-path similarity metrics, such as ScanMatch (Cristino et al, 2010 *Behaviour Research and Methods* 42(3)), identify participants who named a similar sequence of objects. In particular, we investigate cases in which an object is correctly named without being fixated; and fixated without being named. We aim to model this behaviour using a combination of visual (object saliency), contextual and linguistic (word frequency) information.

◆ **Illusory perceptual mislocalization of a spatially extended target does not effect eye movements**

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In order to judge the relative perceptual location of a spatially extended object, or to make a saccadic eye movement to it, an abstract central reference position such as the center of gravity has to be computed. I

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demonstrate a perceptual illusion in which the center of a spatially extended target is mislocalized as a function of its 2D orientation. Observers visually aligned a small dot with the center of an oriented target (an elongated elliptical shape). There was a large misalignment when the target axes were oriented away from the cardinal directions; the size of the misalignment was a function of object orientation and as large as 15% of the major object axis length. However, average landing positions for single saccades made to the object from the comparison dot showed no similar mislocalization bias. Furthermore, perceptual mislocalization varied as a function of the eye-movement/fixation task: fixating the comparison dot when doing the alignment yielded the largest bias, followed by free scanning. The lowest errors were obtained when the oriented target itself was fixated. Taken together, the results suggest that eye movement programming has access to the true center of an object even in situations where its perceptual location cannot be accurately determined. The results bear on the debate regarding differing representations for visual judgments and visually-guided motor actions.

◆ **Why you are more likely to see a snail move if it is surrounded by grasshoppers: Influence of the prior assumption of stationarity on saccadic suppression**

162 M Duyck, M Wexler, T Collins (Université Paris Descartes, France;
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Object displacement often goes unnoticed when it happens around the beginning of a saccade. It has been suggested that this phenomenon, saccadic suppression, results from a combination of three sources of information: retinal, extra-retinal, and the assumption that the world is stable during eye movements. Here, we investigated this issue experimentally using a classic saccadic suppression paradigm. We manipulated the prior assumption stationarity by varying the probability of target displacement around the saccade in two conditions: in the unstable condition, the target jumped on every trial whereas in the stable condition, those jumps occurred on only 25% of the trials. The subjects' task was to maintain fixation on the target and to follow its first displacement, then to report the direction of the second displacement in a 2AFC procedure. Results indicate that saccadic suppression increases in the stable condition compared to the unstable one: subjects are worse at detecting target displacements around the beginning of the saccade when target displacement is rare, than when the target always shifts during saccades. Thus, visual stability mechanisms seem to take into account knowledge regarding the stability of the world, knowledge that can be updated during the course of a two-hour experiment.

◆ **Peripheral spatial frequency processing affects timing and metrics of saccades**

163 J Laubrock, A Cajar, R Engbert (University of Potsdam, Germany;
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The visual acuity gradient with eccentricity and cortical magnification suggests a specialization of foveal vision for high-acuity analysis and peripheral vision for orienting and target selection. How does this specialization affect eye movements? We used Gaussian-envelope gaze-contingent filtering of spatial frequencies in natural scenes and colored-noise images to investigate influences of level-of-detail on saccade amplitudes and fixation durations in free-viewing and search tasks. Filter characteristic (low-pass vs high-pass), filter location (foveal vs peripheral), and filter size were independently varied. Spatial results reveal a preference for targeting regions in the region that was unfiltered during the current fixation, and an additional influence of filter characteristic. Surprisingly, temporal results indicate that peripheral information does play a role in controlling fixation duration. Task influences are mainly visible in how the filter characteristic affects the evolution of durations and amplitudes over the course of the trial. We conclude that both foveal and peripheral vision contribute to how and when we move our eyes.

◆ **Effect of perceptual grouping by similarity on eye movements in processing simple visual stimuli**

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In the present study we analyzed the impact of grouping by similarity on saccadic processing of simple sequential stimuli. We used four sets of stimuli: (1) points, (2) points, triangles, squares, and rhombs (two or more figures of the same shape were followed by two or more figures of a different shape), (3) the 2nd set of stimuli colored according to the shape, and (4) the 2nd set of stimuli with a colored background according to the shape. Stimuli were distributed in the same distance from each other and the size of stimuli was equant. In measuring saccadic amplitudes and stability of gaze during fixations we observed increasing processing load in grouping stimuli. This is reflected in (a) increase of standard deviations of amplitude dispersion in the tasks with grouping effects (additionally the distribution of saccadic

amplitudes is significantly higher in stimuli with grouping effects); (b) increase of small saccades in the grouping tasks, (c) a systematic increase of the amplitude of microsaccades within a fixation time. These observations enable us to confirm two general assumptions: a. the grouping significantly influences saccadic processing of simple visual stimuli, b. the complexity of grouping is reflected in complexity of saccadic processing.

◆ **Eye movement deficits in neglect dyslexia**

- 165 S Primativo¹, L S Arduino², M De Luca³, R Daini⁴, M Martelli¹ (¹Dept of Psychology, Sapienza University of Rome, Italy; Neuropsychology Unit, IRCCS Fondazione Santa Lucia, Rome, Italy; ²LUMSA University, Rome, Italy; ISTC-CNR, Rome, Italy; ³Neuropsychology Unit, IRCCS Fondazione Santa Lucia, Rome, Italy; ⁴Dept of Psychology, University of Milano-Bicocca, Milan, Italy; e-mail: silvia.primativo@uniroma1.it)

Neglect Dyslexia (ND) is an acquired reading disorder often associated with right-sided brain lesions and Unilateral Spatial Neglect (USN). In reading aloud single words patients with ND produce left-sided errors. The reported dissociations between USN and ND suggest that the latter can be interpreted as a selective reading deficit distinct from USN. We analyzed eye movements in USN patients with and without ND (respectively ND+ and ND-) and in a group of controls (right brain-damaged patients without USN) comparing a reading aloud task and a saccadic task (left-right saccade test). Only ND+ patients did left-sided errors and showed an impaired behavior in saccade execution both in reading and in the saccadic tasks. Finally, in a speeded reading-at-threshold experiment, that doesn't allow for eye movements, ND- patients, but not controls, did left-sided errors. Our results indicate that ND+ patients have an impaired eye movement pattern in addition to their spatial attention disorder that exposes the neglect gradient in reading, ND- patients show the same gradient in reading errors when eye movements are prevented. We conjecture that ND rather being a dissociated disorder is the result of the USN syndrome when the fine eye movements required in reading are compromised.

◆ **Reading parallel texts—augmentation and eye movements**

- 166 G Brelstaff¹, F Chessa², L Lorusso², E Grosso² (¹CRS4, Italy; ²University of Sassari, Italy; e-mail: gjb@crs4.it)

The experience of reading translated texts can be augmented by presenting parallel texts, of the source and translation, side-by-side on the page. On screen those texts can be made to dynamically reveal correspondences between their words and phrases (Chessa and Brelstaff, Proceedings of CHIItaly, ACM, 2012). We attempt to assess the utility of such methods by monitoring the reader's eye movements, with and without augmentation—using a Tobii TX300 tracker. The literature on eye movements and reading (eg Rayner *Psychological Bulletin*, 1998; Schultz et al 2001 *Journal of Vision*) has little to say on parallel text appreciation: Nevertheless, a greater number of fixation regressions is a likely consequence of switching gaze between columns of parallel texts. Our results indicate if regression rates improve with augmentation—via on-screen dynamic colour highlighting. We also report variations occurring for the task of reading-while-listening (Levy-Schoen 1981) to the text in either language.

◆ **Post-saccadic location judgments after presentation of multiple target-like objects**

- 167 S Ohl¹, S Brandt², R Kliegl³ (¹Berlin School of Mind and Brain, Germany; ²Charité Universitätsmedizin Berlin, Germany; ³University of Potsdam, Germany; e-mail: svenohl@uni-potsdam.de)

In the present study we examine how the interplay between oculomotor error, secondary (micro-)saccades and available visual information affect post-saccadic location judgments when multiple target-like objects are presented during post-saccadic fixation. During saccade flight the screen presenting the target was replaced by a screen with 63 target-like objects presented horizontally side by side. Subjects were asked to fixate the target and to indicate via mouse click the object they assume to be identical with the pre-saccadic target. Each subject participated in two sessions which differed with respect to whether or not a blank period of 200 ms was inserted between saccade initiation and presentation of the target array. Contrary to our expectation, preliminary analyses did not reveal significantly different location judgments between the blank and no-blank condition. Nevertheless, inserting a blank significantly influenced oculomotor behavior by decreasing the number of secondary (micro-)saccades during an early time window. When subjects generate a post-saccadic eye movement, they strongly tend to choose the object which is fixated after the post-saccadic eye movement. Results are discussed with respect to current mechanisms proposed to underlie the perception of a stable visual world.

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◆ **The effect of compensatory scanning training on visual scanning in hemianopia patients**

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Homonymous hemianopia, the most common form of Homonymous Visual Field Defects (HVFD), refers to a loss of perception for half the visual field, affecting both eyes, due to acquired postchiasmatic brain injury. This partial blindness may lead to a disorganized visual search strategy and particular difficulties with visual exploration. A new Compensatory Scanning Training (CST) protocol has been developed, which aims to improve awareness, scanning and mobility in daily life. The main focus of this training is to teach patients to adopt a systematic scanning rhythm. Among other tests, we administered three visual scanning tests before and after CST in a group of 50 hemianopia patients. The eye movements were registered during a dot counting task, a search task with a parallel and a serial search condition, and a hazard perception task, in which subjects watched photos of traffic situations from the perspective of the car driver. The eye movements on the different scanning tasks before and after CST will be compared, as well as the relationship between scanning strategy and performance, as measured by reaction times and accuracy scores. The hypotheses are that CST has a beneficial effect on scanning and that different search tasks require different scanning strategies.

POSTERS: LEARNING AND MEMORY

◆ **The effect of the subjective congruency of linguistic labels on boundary extension**

169 K Inomata (Graduate School of Kansai University, Japan; e-mail: kntr.inomata@gmail.com)

Boundary extension (BE) is a phenomenon wherein participants remember seeing more of a scene than was actually shown to them (Intraub and Richardson, 1989 *Journal of Experimental Psychology: Learning, Memory, and Cognition* **15**(2) 179–187). In previous studies, boundary extension was investigated by using pictures that contain a main object. Boundary extension was observed when linguistic labels were presented with pictures that did not have a main object (Inomata, 2011 *i-Perception* **2** 958). This suggests that semantic understanding of a scene is necessary to elicit boundary extension. However, it is possible that linguistic labels increase visual information that yields boundary extension. Therefore, this research aims to determine whether a congruency between abstract pictures and linguistic labels elicit boundary extension. Participants were presented with 12 pictures with either a congruent label, an incongruent label, or without any label. After these pictures had been presented, the participants were required to rate the differences between the test pictures and the remembered pictures. Subsequently, they rated the semantic congruency between the pictures and labels. The test pictures were identical to the presented pictures. Results revealed that boundary extension occurred only when labels were congruent with pictures subjectively.

◆ **What level of processing is required to form fast-task irrelevant perceptual learning?**

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Task-irrelevant Perceptual Learning (TIPL) refers to a phenomenon where stimulus features that are irrelevant to participants' tasks are learned when consistently presented with task-targets or rewards (for review see Seitz and Watanabe, 2009 *Vision Research* **49**(21), 2604–10). However, TIPL can fail for salient stimuli (Tsushima, Seitz, Watanabe, 2008 *Current Biology* **18**(12), R904–8). Recently, a fast-form of TIPL was discovered where enhanced memorization of salient target-paired images occurs with as little as a single trial of target-pairing (Leclercq and Seitz *Vision Research*, in press). Here we present results of three experiments that manipulated the level of processing of the target-paired stimuli. Results indicate that TIPL occurs for target-paired stimuli that participants must memorize and also when participants process these stimuli for a secondary task without a memorization requirement. However, no TIPL was observed when participants were asked to ignore the target-paired stimuli. These results suggest that salient stimuli can benefit from TIPL, however, when these stimuli have no value to the participant then they may be inhibited by attention. These results are consistent with recent models of TIPL that suggest that attentional signals can either enhance or suppress learning depending on whether those stimuli are distracting or not to participants' objectives.

◆ **Always trust the congenitally blind man**

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Human memory has been found to be easily influenced by the nature of the learnt material, such as when lists of semantically related words are learnt. In this case we are likely to report words that were not in the list, but which are related to them, namely 'false memories'. Here we investigated the role of visual experience on false memory generation. Previous studies suggested that congenitally blind people possess superior verbal-memory and verb-generation skills. Additionally, visual cortex was active during these memory tasks. We tested congenitally, late blind, and sighted participants by adopting the false memory paradigm. Results showed that congenitally blind participants were less affected by false memories than the other two groups. Moreover, congenitally blind participants reported more words from the original. That is, they might 'stick' closely to the words they heard rather than being 'fooled' by semantic associations across them. The extensive structural and functional reorganisation in congenitally blind's brain, especially across visual areas, might provide the neural bases for these superior verbal memory skills.

◆ **Short-term changes in expectations flexibly modulate the appearance of ambiguous stimuli**

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Expectations can shape the way we perceive the world. Here, we tested whether short-term changes in expectations modulate the perception of ambiguous visual stimuli. Participants performed a probabilistic learning task. High or low tones were associated with right- or leftward rotation of sphere stimuli that were disambiguated by disparity cues. Randomly interspersed were ambiguous versions of the sphere without disparity cues but indistinguishable in appearance from the unambiguous stimuli. The association between tones and rotation direction changed unpredictably in a probabilistic fashion every 16 to 32 trials. Participants indicated rotation direction and their confidence about the reported percept on every trial. Stimulus-response mapping was randomised across trials to ensure that button presses were uncorrelated with participants' perception. In unambiguous trials, reaction times were faster matching the predominant tone-rotation association in a given block compared to non-matching stimuli. Most importantly, ambiguous stimuli were more frequently perceived as rotating in the direction matching the currently predominant association. This effect was also observed when only considering trials with the highest confidence level and correlated with the effect of reaction times in unambiguous trials. These results indicate that even rapidly changing prior expectations strongly influence the contents of our visual experience.

◆ **Using recollection and familiarity to investigate view generalization in object recognition**

173 W Hayward (University of Hong Kong, Hong Kong; e-mail: whayward@hku.hk)

Objects can sometimes be recognized across changes in view with relatively trivial costs to performance, but at other times even a small change in viewpoint can result in large recognition impairments. One way to explain this apparent contradiction is whether the memory experience of the object is based upon the entire encoding episode (also termed "recollection") or whether it is based on the object itself, devoid of context (called "familiarity"). In two experiments, different techniques were used to separate recollection and familiarity judgments for rotated objects. Participants studied familiar objects and then had to perform recognition judgments for the objects across changes in rotation. In experiment 1, participants had to remember the temporal context of the objects, and the process-dissociation procedure was used to get independent estimates of recollection and familiarity. In experiment 2, the "Remember-Know" procedure was used to assess participants' memory experiences for each object, and again separate estimates of recollection and familiarity were obtained. Both studies showed that recollection was influenced by the similarity between views at study and test, but familiarity was viewpoint invariant. These results show that information is routinely encoded from objects to support both view-specific and view-invariant patterns of recognition.

◆ **Nicotine facilitates memory consolidation in perceptual learning**

174 A Beer¹, D Vartak², M Greenlee¹ (¹University of Regensburg, Germany; ²Netherlands Institute for Neuroscience, Netherlands; e-mail: mark.greenlee@psychologie.uni-regensburg.de)

The neurotransmitter acetylcholine is known to enhance performance in perceptual tasks. However, little is known about the role of the cholinergic system for implicit memory consolidation processes in perceptual learning. Here we compared two groups of non-smoking men who learned the same

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visual texture discrimination task (TDT). Following the TDT training, one group received chewing tobacco containing nicotine for one hour. The other group received a similar tasting control substance without nicotine. Participants were randomly assigned to the groups and blind to the substance. Electroencephalographic (EEG) recordings during substance consumption showed a reduced alpha activity and P300 latency in the nicotine group compared to the control group. When re-tested on the TDT the next day, both groups responded more accurately and more rapidly than during training. These improvements were specific to the retinal location and orientation of the texture elements of the TDT suggesting that learning involved early visual cortex. A group comparison showed that learning effects were significantly more pronounced in the nicotine group than in the control group. The EEG findings suggest that oral consumption of nicotine enhances the efficacy of nicotinic acetylcholine receptors. Our findings further suggest that enhanced efficacy of acetylcholine receptors facilitates the consolidation processes involved in perceptual learning that take place following task completion.

◆ **Individual differences in semantic and spatial scene gist processing**

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Scene gist processing is influenced by individual differences in speed of perceptual processing (Võ and Schneider, 2010 *Visual Cognition* **18**(2) 171–200). As both spatial and semantic content is supposed to be influential during scene gist processing, the current study explored whether verbal and spatial skill differences would independently affect scene gist processing. 75 university staff and students participated. Short versions of the Alice Heim test (AH5) assessed spatial and verbal skills. judgments of whether or not sentences matched pictures and judgments of the relative spatial location of probe objects were carried out on separate sets of photographs. For half the trials in each task, a 250 ms preview of the picture (without sentences or probe objects) preceded the judged picture. Spatial and verbal skills were highly correlated, so partial correlations were used to measure skill to task relationships. Spatial skill correlated significantly with preview benefit in the spatial task, but not with spatial task performance itself, nor with preview benefit or base performance on the sentence task. Verbal skill did not correlate significantly with anything. The two preview benefits did not correlate significantly with each other. Thus, spatial skill but not verbal skill affects early processing of scenes.

POSTERS: RETINA

◆ **Spatial weighting of visual motion coding in manual following response and MEG**

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Visual motion information is not only used for perception of external world, but also instantaneously used for motor behaviors. It was found that a large-field visual motion induces a short latency manual response during reaching, termed Manual Following Response (MFR). To understand its generation mechanisms, we examined the spatial integration characteristics of MFR and related MEG (magnetoencephalography) response. As stimulus size increased, the MFR amplitude markedly increased for the lower-SF stimuli (0.02, 0.05 c deg⁻¹), but not much for the higher-SF stimuli (0.2, 0.8 c deg⁻¹). The identical stimuli were utilized to characterize the visually evoked MEG responses. MEG responses, mainly originating from the temporo-occipital cortex, were highly correlated with the MFR as shown previously (Amano et al, 2009 *Journal of Neurophysiology* **101** 888–897), but some difference was found in their tunings for stimulus size. Sensitivity functions fitted by Gaussian indicate that spatial integration is wider for the MFR than for the MEG with lower-SF stimuli while it is narrower for the MFR than for the MEG with higher-SF stimuli. These results suggest that the motion signal integration for the MFR relatively weights the neural activities sensitive to the lower-SF stimuli on the visual periphery while MEG reflects more parafoveal neural activities.

◆ **MEG evidence for early sensitivity to spatial phase congruency in human primary visual cortex**

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Salient features in images, such as edges and lines, have been shown to correspond to points where spatial frequency components across spatial scales are maximally in phase, ie, at locations of maximal phase

congruency. Recent functional magnetic resonance imaging (fMRI) studies suggest that human visual cortex, including the primary visual cortex (V1), is sensitive to the phase congruency information (Henriksson et al, 2009 *Journal of Neuroscience* **29**(45) 14342–51; Perna et al, 2008 *Journal of Vision* **8**(10) 15 1–15). However, given the limited temporal resolution of fMRI, it has remained unclear whether this sensitivity originates in V1 or in a higher-level visual area. In this magnetoencephalography (MEG) study, we compared responses for compound grating stimuli with congruent and random phase alignments. We observed greater activity for the congruent stimuli first in V1, already within 100 ms after the stimulus presentation (Wilcoxon's signed rank test across subjects, $N = 10$, $p < 0.05$), and only later in higher-level visual areas. These results imply an early origin for phase congruency sensitivity in V1, and support the hypothesis that this information is used by the human visual system to locate natural broadband edges.

◆ **Visual discrimination performance dependence on the individual peculiarities of the retina structures**

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Recently growing interest to possible association of amblyopia with structural changes in retina makes it important to investigate the dependence of the human normal visual acuity on the peculiarities of macular retina structures (Repka et al, 2006 *American Journal of Ophthalmology* **142**(2) 247–251; Cagini et al, 2009 *Current Eye Research* **34**(12) 1036–41; Tsilimbaris et al, 2012 *Ophthalmologica*, Apr 4, Epub ahead of print). In this work the correlation between human ability to discriminate small features of visual objects and individual characteristics of macular retina structures was investigated. During the discrimination task subjects had to define the orientation of the Landolt C elements with different sizes, noise levels and presentation modes: monocular and binocular. The probability of the correct answer was used as a measure of subjects' visual acuity. Optical coherent tomography method was used to measure the individual features of subjects' retina, such as ratio of the foveola and fovea diameters (ff-ratio), and retina thickness in different macular regions. First results show that subjects with thinner retina in the fovea area and ff-ratio closer to unity demonstrate better performance in the discrimination task. The results are discussed in terms of the monocular versus binocular vision model and the limiting factor of the internal multiplicative noise formed by the retinal structures.

◆ **Visual hyperacuity estimated with apparent motion**

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To investigate visual acuity 2-dot stimuli were used with the angular sizes about 6 arcsec and 7 arcsec spacing produced by LEDs and plastic light guides. Visual acuity is considered as the minimum angular distance between two luminous dots for which the visual system reacts as on separated light sources. Rather than asking the subject whether one or two dots were presented, indirect judgments about visible displacement, an apparent motion and flicker were used. Detection of any of these phenomena indicates that the visual system responds on two dots, not on one. According to our preliminary findings, detection of flicker and displacement occurs at angular distances about 14 arcsec, and apparent motion detection at 16–20 arcsec, that agrees with vernier visual acuity thresholds, but less than angular cone size. The plausible explanation is that the retina should be considered as quasiperiodic 3D structure. Hence, even with very small stimuli and displacements (less than cone sizes) the light field has sophisticated distribution within the thickness of retina. Than the large set of photoreceptors is excited.

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WEDNESDAY

POSTERS: ADAPTATION

◆ **Ecological visuomotor tasks during prism adaptation cause larger aftereffects than repeated pointings in healthy participants**

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Prism adaptation (PA) is an effective procedure for improving spatial neglect (Rossetti et al, 1998 *Nature* **395**(6698), 166–169). Recently, an ecological PA protocol (Fortis et al, 2010 *Neuropsychology* **24**(6), 681–697) was developed, consisting in executing visuomotor activities manipulating daily-life objects. This approach, combined with the classic repeated pointing method (Frassinetti et al, 2002 *Brain* **125**(3), 608–623), provided encouraging results in a recent study in right-brain-damaged patients with left neglect. Here, we compared the two paradigms in young and elderly healthy participants, to assess putative similarities and differences in producing adaptation and aftereffects. Participants underwent PA in two consecutive days, in which they performed the two tasks. In pre- and post-exposure sessions, participants performed three “straight-ahead” tasks (proprioceptive, visual, visuo-proprioceptive). Results showed adaptation to both treatments. Interestingly, the “ecological approach” induced greater aftereffects in the proprioceptive (young and old groups), and in the visual and visuo-proprioceptive tasks (young group only), and was rated as more enjoyable by participants. These results highlight the efficacy of the “ecological” PA paradigm, which appears to be more effective than the traditional pointing procedure in bringing about aftereffects, whose size appears to be related to the PA-induced improvement of neglect.

◆ **Filling-in with afterimage after MIB without adaptation while MIB**

² R Shohara, M Katsumura, S Naito (Human and Information Science, Tokai University, Japan; e-mail: snaito@keyaki.cc.u-tokai.ac.jp)

Introduction: The Motion Induced Blindness (MIB) is supposed that its origin is V2 or higher and MIB is independent of V1 adaptation. We examined a simple and undeniable justification that the filled-in luminance or color by MIB never led any adaptation. Methods: On the red background the 8 yellow filled circles with 3.5 degree diameter were arranged at 10 degree diameter circle periphery. Each of the yellow circles was disappeared in turn in a rotation manner by MIB. (1) We conducted the prolonged observation of filling-in color, while MIB we examined whether any aftereffects or adaptations were perceived. (2) The half of the targets remained appeared without MIB. After prolonged observation, we examined the afterimages whether any difference between MIB and no-MIB areas was perceived. Results: (1) We perceived the red filling-in color which was exactly the same to the background and never changed while prolonged observation. (2) We perceived exactly the same afterimage for the no-MIB and MIB area, one was always a real yellow, the other was the half chance of the yellow and the other half chance of filled-in red. Conclusions: Filling-in by MIB was at least at the higher visual area than the adaptation was relevant.

◆ **MIB and filling-in with transient change of background, target or both**

³ M Katsumura, R Shohara, S Naito (Human and Information Science, Tokai University, Japan; e-mail: snaito@keyaki.cc.u-tokai.ac.jp)

Introduction: The conventional Motion Induced Blindness (MIB) requires that the background and target should be unchanged for maintaining adaptation while the inducing texture is moving. (1) We changed the background or target luminance and color at the moment of disappearance and examined MIB. (2) We changed the background while the target was invisible by MIB such a way that after the black background adaptation, at the moment of disappearance the background was changed to dark yellow then, while MIB, it tuned to be blue then black again. We examined MIB, if not destroyed, what percepts were obtained. The findings suggested the novel independence of the adaptation for filling-in of MIB. Methods: The two white stationary filled circles with 6.5 degree of diameter were presented at 8 degree upper and lower of the center fixation point. The 5 white concentric rings appeared at the

border of the circle and expanded to 8 degree radius consecutively and disappear at 8 degree radius in 1000ms, in an alternating manner at the upper or lower circle. Results: We perceived the newly changed background color after disappearance for all experiments. Conclusions: MIB and Filling-in did need the fixation, but not necessarily needed the adaptation.

◆ **Top-down control modulates face aftereffects**

⁴ P Pallett¹, D MacLeod², M Meng¹ (¹Dartmouth College, USA; ²University of California, San Diego, USA; e-mail: ppallett@gmail.com)

Adaptation is often coined the psychophysicist's electrode. Accordingly, studies of face aftereffects indicate that face processing relies upon norm-based coding mechanisms. Here we tested whether face aftereffects are influenced by top-down control or purely bottom-up driven. Participants discriminated differences in typicality and eye-to-mouth distance while adapted to either a vertically compressed or vertically elongated face. Notably the stimuli and procedure were identical for both tasks, thus the only variable was top-down in nature (ie, task type). As expected, we observed significant aftereffects for the typicality judgments. Adaptation to the compressed face produced a perceived "normal" that was more compressed than the original, undistorted face. Similarly, adaptation to the elongated face produced a perceived "normal" that was more elongated than the original, undistorted face. By contrast, we found no effect of adaptation on eye-to-mouth distance discrimination. This could occur if participants used analytical processing to isolate and compare the visual angles between the eyes and the mouth of each face; such a comparison should be unaffected by shifts in the perceived norm of faces. These results suggest that top-down control can produce qualitative differences in the neural encoding of faces.

◆ **Reduced face identity aftereffects in relatives of children with autism**

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Autism is a developmental condition with complex etiology. To aid the discovery of genetic mechanisms, researchers are trying to identify potential endophenotypes—subtle neurocognitive traits present in individuals with autism and their "unaffected" relatives. Relatives of individuals with autism often exhibit face processing atypicalities, which are similar in nature albeit of lesser degree, to those found in individuals with autism. However, the mechanisms underlying such atypicalities have yet to be clarified. We investigated whether atypicalities in adaptive norm-based coding of faces are present in relatives of children with autism, similar to those reported in children with autism (Pellicano et al, 2007 *Current Biology* 17 1508–1512). To test this possibility, we administered a face identity aftereffect task in which adaptation to a particular face biases perception towards the opposite identity, so that a previously neutral face (ie, the average face) takes on the computationally opposite identity. Parents and siblings of individuals with autism showed significantly smaller aftereffects compared to parents and siblings of typically developing children, suggesting that adaptive face-coding mechanisms might be less efficient in relatives of children with autism. This finding suggests that diminished adaptive mechanisms may represent a neurocognitive endophenotype for autism.

◆ **In pursuit of afterimage perception: Interactions with eye movements and contours**

⁶ G Powell, A Bompas, P Sumner (Cardiff University, UK; e-mail: powellg7@cf.ac.uk)

Observers have long been directed to avoid making eye movements during colour afterimage experiments, with the assumption that they suppress afterimage visibility. One hypothesis is that saccadic eye movements lead to afterimage suppression because they distinguish an illusory afterimage from a real stimulus in a way that fixation cannot. Unlike an afterimage, no real stimulus remains at the same retinal location after a saccade, providing a cue that the afterimage is not real. Thus, pursuit eye movements would be less likely to result in afterimage suppression as real objects can remain predominantly stationary on the retina when pursued. Contrary to these predictions, we found no difference in afterimage duration in conditions when observers made saccadic and pursuit eye movements and when their eyes remained fixed. We also explored whether providing an additional cue that the afterimage may be real—a surrounding luminance contour—influenced afterimage duration across eye movement conditions. Results revealed that afterimage duration in the pursuit and fixation conditions was increased by the contour to a

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greater extent than the saccade condition. Thus, while eye movements appear not to interact directly with afterimage perception, saccades may alter their perception by interacting with other cues known to enhance afterimages.

◆ **Race-contingent face aftereffects: A result of perceived racial typicality or racial categorisation?**

7 O S Gwinn, K Brooks (Macquarie University, Australia; e-mail: kevin.brooks@mq.edu.au)

Models of face perception suggest that faces are perceived with reference to face 'prototypes' or 'norms'. Research has shown that race-contingent aftereffects can be simultaneously induced using faces of two different races, distorted in opposite directions, as adaptation stimuli. Subsequently, a test face of a certain race will appear transformed in a manner consistent with the adaptation images used for that race, suggesting the existence of multiple prototypes. We examined whether race-contingent aftereffect size is predicted by levels of perceived racial typicality or by dichotomous racial categorisation. In experiment 1, faces with a range of 'morph levels' (ie relative contributions of Asian/Caucasian faces) were either rated on a continuous scale for Asian/Caucasian typicality, or simply categorised as Asian/Caucasian. As expected, typicality ratings showed a shallow slope (observers were sensitive to morph level over a broad range), while dichotomous racial categorisation showed a steep slope (rapid switch from categorisation as Asian-Caucasian). In experiment 2, race-contingent adaptation was assessed using test faces with various morph levels. Aftereffect size showed a shallow slope, more closely resembling racial typicality than categorisation data. This suggests that faces are not exclusively coded against one prototype, but instead the visual channels processing faces are broadly tuned.

◆ **Influence of visual illusions on some dynamic parameters of human vertical posture**

8 S Rychkova, N Holmogorova, G Rozhkova (Moscow City Psychological and Pedagogical University, Russian Federation; e-mail: gir@iitp.ru)

The visual system exerts both a nonspecific and a specific influence on human vertical posture. The first one depends upon the ambient illumination level. It is mediated through a modulation of the postural muscle tone. The second one depends upon the spatial interpretation of the visual input. The visual systems of internal body and external space representation are involved in the control of the reference positions and the postural reactions. We studied the influence of visual illusions on human vertical posture. The stabilograms and ballistograms were recorded in 20 young adults (aged 18–25 years) who had to maintain a vertical posture under various visual conditions. The visual stimuli included dynamic patterns that evoked the stereokinetic illusion of depth (SKI) or the illusion of ambiguous rotation (ARI). In some experiments, the subjects wore goggles producing a horizontal visual inversion (HVI). The greatest changes in the control parameters of the dynamic stabilization of the vertical posture were observed under monocular viewing conditions the case of SKI. HVI had no significant influence in the case of SKI but, in the case of ARI, was always accompanied by an increase of the dynamic indexes.

◆ **The positional motion aftereffect is spatially selective in world coordinates**

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We measured spatiotopicity with the classical motion aftereffect (illusory motion following adaptation to motion) and the positional motion aftereffect (the change in apparent position after adaptation to motion). Subjects adapted to small (1°) vertically aligned patches of gratings (1 c deg s⁻¹), drifting in opposite directions at 3 deg s⁻¹. They saccaded 12° rightwards to a target, then test gratings (same size and spatial frequency) appeared for 500 ms, in the same retinal or the same screen position (or both, with no intervening saccade). The MAE was strictly retinotopic, but the PMAE showed a strong spatiotopic component. We also measured the PMAE with test gratings that were apparently stationary (with illusory MAE annulled) and found that under these conditions, the effects were almost entirely spatiotopic, with no statistically significant retinotopic component. Finally we measured the time required to generate a spatiotopic representation. After displaying the saccade target, we waited for a variable period before extinguishing the fixation point, the signal to saccade. For short exposure of the saccade target (300 ms) the effects were more retinotopic, for longer durations more spatiotopic. The results provide clear evidence for a spatiotopic map in humans, which takes time to build up.

◆ **Motion-form interactions beyond the motion integration level: psychophysical evidence for interactions between orientation and optic flow signals**

10 G Mather¹, R Bellacosa Marotti², A Pavan³ (¹University of Lincoln, UK; ²Università degli Studi di Padova, Italy; ³Universität Regensburg, Germany; e-mail: gmather@lincoln.ac.uk)

Motion and form encoding is closely coupled in the visual system. A number of physiological studies have shown that neurons in the striate and extrastriate cortex (eg, V1 and MT) are selective for motion direction orthogonal to their preferred orientation, but some neurons also respond to motion parallel to their preferred spatial orientation. Recent psychophysical research (Mather et al, 2012 *Neuropsychologia* **50**(1) 153–159) has demonstrated that the strength of motion adaptation is modulated by simultaneously presented orientation signals, and suggests that the interaction occurs at the level of motion integrating receptive fields in extrastriate cortex. In the present psychophysical study we investigated whether motion-form interactions take place at a higher level of neural processing where optic flow components are extracted. We measured the duration of the motion after-effect (MAE) generated by contracting or expanding dot fields in the presence of either radial (parallel) or concentric (orthogonal) counter-phase pedestal gratings. The results showed that motion adaptation (as measured with the MAE) is suppressed most by orientation signals orthogonal to optic flow direction, suggesting that motion-form interactions also take place at the level where optic flow is processed.

◆ **The role of stationary and dynamic test patterns in rapid forms of motion aftereffect**

11 M Skujevskis¹, A Pavan² (¹SISSA—Cognitive Neuroscience Sector, Italy; ²Universität Regensburg, Institut für Psychologie, Germany; e-mail: andrea.pavan@psychologie.uni-regensburg.de)

Sub-second adaptations to directional motion can produce motion aftereffect (MAE). Unlike the characteristics of the classical MAE—produced by adaptations of several seconds up to minutes—the properties of the rapid form of MAE (rMAE) have been less well explored. In a series of experiments, we assessed the role of stationary and dynamic test patterns (counter-phase flickering gratings) in generating rMAE. In particular, we varied the duration, temporal frequency, and spatial phase of the adapting stimuli. Our results revealed that the strongest rMAE is produced when using dynamic test patterns. The dynamic rMAE shows a strong dependency on the adaptation duration and temporal frequency, but not on the spatial phase of the adapting pattern. In addition, similarly to the classical dynamic MAE, the temporal frequency tuning of the dynamic rMAE suggests the involvement of both low-pass and band-pass visual channels. In contrast to the dynamic rMAE, our results did not show any evidence for the static rMAE, suggesting, in addition to some recent physiological and psychophysical findings, that the static rMAE is primarily dependent on the properties of the stimuli and the specific experimental procedures employed.

◆ **Retinal and extra-retinal motion aftereffects compared**

12 T C Freeman¹, E Boot¹, H Brown¹, J R Davies² (¹Cardiff university, UK; ²University of Bristol, UK; e-mail: freemant@cardiff.ac.uk)

Recent work has shown that extra-retinal motion aftereffects (erMAE) exhibit properties that are distinctly different from retinal motion aftereffects (rMAE). In particular, adapting to reflexive eye movements produce erMAE that does not store, while oblique pursuit produces erMAE that changes direction over time. Here we provide further evidence of marked differences between erMAE and rMAE. Experiment 1: Following adaptation to pursuit or retinal motion, a small stationary test presented in complete darkness produced negligible rMAE (mean duration 0.8s) but compelling erMAE (17.2s). Conversely, when the test was surrounded by a large texture field, rMAE was now seen (4.7s) and erMAE considerably reduced (4.4s). Experiment 2: erMAE was strongly modulated by adaptation direction, with durations following horizontal pursuit at least half that following vertical pursuit. For high frequency adaptation (1Hz sawtooth wave), upward pursuit produced much longer erMAE (8.7s) than either downward (4.3s) or horizontal (2.9s). Conclusions: The reduction of erMAE by a texture field suggests that a non-retinotopic extra-retinal signal can, during MAE, be downweighted in favour of a stationary prior. On the other hand, the effects of direction on erMAE would seem to reside at an earlier stage of processing, perhaps within the oculomotor system itself.

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◆ **The reference frame of the motion aftereffect**

- 13 N Nikolova, S Raphael (Max Planck Institute for Neurological Research, Germany; e-mail: nikolova@nf.mpg.de)

We examined the reference frame of the motion aftereffect to centripetally or centrifugally moving dots. The strength of the after effect was measured by matching the perceived velocities of transparently moving expanding and contracting dots in a briefly presented test (350ms). The test was always positioned in the center of the screen. In the Control-condition the fixation point, and the focus of expansion/contraction of the adaptor was in the center of the screen. In the Roaming-Fixation (RF) condition the focus of the adaptor was in the center of the screen and the position of the fixation point was changed randomly along the 4deg circumference from the center of the adaptor once every second. Thus any given retinal point received a mixture of adapting motion directions over time. In the Roaming-Adaptor (RA) condition fixation was kept steady but the focus of expansion/contraction of the adaptor changed randomly along the 4deg circumference from the fixation point once every second. Results: The strongest effect of adaptation was observed in the Control-condition. Weaker adaptation was found in the RF condition, whereas in the RA condition the effect was negligible. Conclusion: The reference frame for centrifugal and centripetal movement is not entirely spatiotopic or retinotopic.

◆ **Crossmodal adaptation aftereffects following observation of human hand actions**

- 14 S Page¹, N Barraclough² (¹University of Hull, UK; ²University of York, UK; e-mail: n.barraclough@psych.york.ac.uk)

Repeated exposure (adaptation) to visual actions can induce adaptation aftereffects biasing subsequent perception of visual actions (Barraclough et al, 2009 *Journal of Cognitive Neuroscience* **21** 1805–1819). Crossmodal aftereffects have been observed to more simple stimuli, for example adaptation to visual motion in depth causes auditory loudness aftereffects (Kitagawa and Ichihara, 2002 *Nature* **416** 172–174). In order to investigate multimodal action coding, we tested whether action sound perception was influenced by prior adaptation to different stimuli (auditory only, visual only, or audiovisual representations of actions). After adapting to auditory action sounds (hand knocking and hand slapping), subsequent test stimuli (blended ‘knock’ and ‘slap’ sounds) sounded less like the adapting stimulus, a repulsive auditory aftereffect. This auditory aftereffect showed a characteristic increase with repetition of the adapting stimulus. We also observed significant crossmodal aftereffects following audiovisual and visual only adaptation. These high-level crossmodal aftereffects suggest multimodal coding of actions in humans, and may result from adaptation in multimodal neurons selective for actions as have been found in the monkey (Barraclough et al, 2005 *Journal of Cognitive Neuroscience* **17** 377–391).

◆ **Adaptation transfer effects are moderated by the similarity to the adaptors**

- 15 S Faerber¹, C C Carbon² (¹University Bamberg, Germany; ²Dept of General Psychology and Methodology, University of Bamberg, Germany; e-mail: stella.faeber@uni-bamberg.de)

Most studies on visual adaptation refer to adapting within identical material between adaptation and test. Here we extend the adaptation literature by systematically investigating the impact of similarity between adaptation (inspection) and test (rating) phase on the size of adaptation. To get deeper knowledge on the impact of such adaptation processes on aesthetic dimensions, we employed two important variables of aesthetic appreciation (typicality and liking) within a test-adaptation-test paradigm. We used four 3D-based models of chairs as stimulus material, varying on two design dimensions (proportion and colour saturation). Three out of the four models differed in their similarity to the adaptor chair model (transfer condition), while the fourth model was identical with the adaptor chair (no-transfer condition). As predicted we found significant adaptation effects for typicality as well as liking in the no-transfer condition. More importantly, we found adaptation effects for the transfer condition with similarity of the regarding chair model to the adaptor model being positively related to the size of the effects. These results are discussed in a theoretical framework where we propose a recalibration mechanism of the central prototype or norm within a multidimensional space framework moderated by the distance of each exemplar to the adaptor.

◆ **Effects of perceived strength of illusory contours on tilt aftereffects**

- 16 G Singh¹, G Erlikhman², T Ghose¹, Z Liu² (¹University of Kaiserslautern, Germany; ²University of California, Los Angeles, USA; e-mail: tandraghose@gmail.com)

We examined the tilt after-effect (TAE) for illusory contour stimuli, similar to those in Paradiso, Shimojo, and Nakayama (1989 *Vision Research* **29**), where two groups of half-circles faced each other, with their arc-ends precisely aligned to form a sharp-IC (“Normal-IC”). We weakened illusory contour strength in

two ways: (1) by adding randomly sized rings to the arc-ends that support the contour “Ringed-IC”, and (2) by changing the overlap between the arc-ends by a constant angle “Perturbed-IC”. We compared TAE for these conditions to the Normal-ICs in a 2X2 design. Adaptors were oriented at 15 deg or -15 deg (0 deg was vertical). The test orientations were ± 1 deg, ± 1.5 deg, ± 2 deg, and ± 2.5 deg, interleaved randomly. Subjects indicated whether the test stimulus was tilted to the left or right. Subjects’ perceived vertical was measured prior to adaptation. Surprisingly, the sigma (1/slope) of the fitted psychometric functions was greater for Normal-ICs than the Ringed-IC or Perturbed-IC. We also found that the magnitude of the TAEs was positively correlated with the variance of the perceived vertical. Moreover, sigma increased with adaptation for all stimuli. These results suggest that TAE magnitude is predicted by the noise of the tilt-estimation processes rather than the perceived strength of IC.

◆ **How expectation changes the appreciation of arts**

17 P Kraemer, C C Carbon (Dept of General Psychology and Methodology; University of Bamberg, Germany; e-mail: ccc@experimental-psychology.com)

Information about authenticity seems to be very important in appreciating artworks due to the relevance of originality in the fine arts. To examine the influence of authenticity regarding the evaluation of arts, we exposed participants in a within-subject-design to famous pictures which were labelled as originals or copies, although both versions were physically the same. As we were mainly interested in participants’ spontaneous impressions, we asked them to firstly describe the pictures verbally, followed by ratings on several explicit scales. We found evidence, that so-labelled genuine pictures were rated higher than so-labelled copies on the explicit scales of suitability of used colours, general appreciation, painter’s talent and quality of the picture. Results of qualitative data analysis further indicated that genuine pictures are more appreciated due to suitability of colours. Most importantly, the qualitative analysis of the given statements pointed to important directions of the specific cognitive processes being in action when people perceive so-called “originals” vs “fakes”. For instance most statements referred to colours which could mean that assumed differences among the pictures are suspected in colour in the first place. In sum, this study underlines the importance for an artwork of being unique to be evaluated as masterpiece.

◆ **The boundary conditions of priming of attentional choice: From passive viewing through task-relevant working memory load**

18 A Kristjansson¹, S Saevarsson², J Driver³ (¹University of Iceland, Iceland; ²Bogenhausen University Hospital, Munich, Germany; ³University College London, UK; e-mail: ak@hi.is)

Priming of attentional choice has been shown to have a dominating effect upon attentional shifts and is thought to play a decisive role in visual stability between shifts. Despite this importance, the nature of the memory representations underlying priming remain controversial, and the processing necessary and sufficient for such priming to occur is not well understood. To understand more fully the necessary conditions for priming we contrasted passive versus active viewing of visual search arrays in experiment 1. There was no priming from passive viewing of search arrays, while it was strong for active search of the same exact displays. In experiment 2 we introduced working memory load during visual search in an effort to disrupt priming. The observers had to perform visual search while retaining in memory visual search arrays similar to the ones that they searched. The memorized items had either the same or different colors from the visual search items. Retaining items in working-memory abolished priming of the working-memory task-relevant colors, while interference was miniscule for unrelated colors. The picture that emerges of priming is that it requires active attentional processing of the search items in addition to the operation of visual working memory, where task-relevance of the working-memory load plays a key role.

◆ **High attentional load improves saccadic adaptation**

19 P Gerardin¹, A Farne², D Péliou² (¹Inserm U846 Stem-Cell and Brain Research Institute, France; ²U1028; CNRS UMR5292; Lyon Neuroscience Research Center, IMPACT Team, France; e-mail: peggy.gerardin@inserm.fr)

Adaptation processes maintain saccade accuracy against various events (eg growth, aging, neuromuscular lesions). The adaptation substrates for reactive and voluntary saccades (Gerardin et al, in press *NeuroImage* doi: 10.1016/j.neuroimage.2012.03.037) closely match the cortical substrates of exogenous and endogenous attention control (Corbetta and Shulman, 2002 *National Review of Neuroscience* 3(3) 201–215). However, it is still unknown whether attention can directly affect saccadic adaptation. To test this hypothesis, we manipulated attention during adaptation by combining a perceptual task with an

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adaptation double-step paradigm. During the on-going saccade, the target was simultaneously shifted (to induce adaptation) and changed into a Gabor patch of randomized orientation. Eight subjects performed, in a counterbalanced order, two adaptation sessions that only differed in the task difficulty: in the 'Easy' session subjects had to report whether the Gabor was tilted horizontally or vertically whereas in the 'Challenged' session, subjects reported whether the Gabor was slightly tilted to the left or to the right. Our results show that the build-up and retention of saccadic adaptation induced by the repetition of stepping targets were larger in the 'Challenged' than in the 'Easy' perceptual task. These results support the hypothesis that attention affects adaptation of saccades.

◆ **Visual search with covert adapted saccades**

20 A Meermeier, K Havermann, M Lappe (Institute for Psychology, University of Muenster, Germany; e-mail: a_meermeier@hotmail.de)

Covert visual search may involve covert eye movement planning processes to shift attention within the search display. Saccadic adaptation is a process by which the amplitude of a saccade to a visual target is shortened, such that target location and saccade landing position become dissociated. Saccadic adaptation influences perceptual localization and perhaps deployment of attention. The present study examines the effect of saccadic adaptation on reaction times in a visual search task. The search task implied an overt and a covert condition, differing in whether the execution of saccades was allowed or not. Performance was measured by the reaction times subjects needed to find a target letter out of an array of twelve different letters. Thirteen subjects participated in an experiment consisting of a baseline measurement of search performance, a phase of saccadic adaptation, and a post-adaptation measurement of search performance. Saccadic adaptation was hypothesized to interfere with visual search resulting in elongated reaction times. In both conditions this effect of elongated reaction times after adaptation of eye movements was found. Thus saccadic adaptation indeed affects covert visual search. These findings suggest that covert saccade planning processes are involved in visual search.

◆ **Dividing attention into multiple modalities impairs the motor-visual temporal recalibration**

21 M Tsujita¹, M Ichikawa² (¹Chiba University Graduate School of Humanities and Social Sciences, Japan; ²Chiba University, Japan; e-mail: tsujita@chiba-u.jp)

Prolonged exposure to fixed temporal lag between participant's keypress and visual feedback recalibrates motor-visual temporal relationship, and consequently shifts the point of subjective simultaneity (PSS) in subsequent temporal order judgments between the keypress and visual flash (Stetson et al *Neuron* **51** 651–659). In this study, we examined whether dividing attention into different sensory modalities affected the adaptive shift. In the adaptation phase, the participants constantly pressed a key accompanied by a visual feedback. We injected 0ms or 200ms fixed temporal lag between the keypress and visual feedback. In addition, we presented either of visual flashes around the fixation point or auditory beeps as targets for attention task in each block. In the test phase, the participants conducted temporal order judgment between the keypress and visual flash. If participants attended to the visual targets in the adaptation phase, PSS shifted significantly although, if they attended to the auditory targets, there was no significant shift in PSS. These results suggest that the high level cognitive processing, such as attention, plays important roles in the temporal recalibration, and that turning attention away the modality which is engaged in the motor-visual temporal relationship impairs the adaptive shift.

◆ **Lightness constancy can be enhanced by optimal exploratory gaze**

22 R Lee, H Smithson (University of Oxford, UK; e-mail: robert.lee@psy.ox.ac.uk)

We perceive the lightness of surfaces as relatively invariant across illumination conditions. The corollary of such constancy is that when the luminance of light reaching the eye from two differently reflective surfaces under differing illumination is the same the two surfaces appear different, as seen in Adelson's Checker Shadow illusion (Adelson, 1995, [ion.html](#)). The apparent similarity of these surfaces, however, depends on the amount the observer moves their gaze around the image. We measured eye-movements as observers made relative judgments of the lightnesses of reference and test probes that were superimposed on two patches with different reflectances but identical luminances. We found a relationship between the spatial extent of exploratory eye movements and the shift in the point of subjective equality when the reference was presented on one or other patch. If eye movements sample regions of the image that fall under the same simulated illumination, local adaptation with an extended time-course can produce retinal regions adapted to one or other illumination. Secondly we compared conditions in which eye movements were directed to sample across vs within illumination regions. We analysed the observed

differences between conditions in terms of an adaptation model with particular spatial and temporal summation constants.

◆ **Adaptation to binocularly fused colors**

- 23 H Yamano¹, E Kimura² (¹Graduate School of Humanities and Social Sciences, Chiba University, Japan; ²Dept of Psychology, Faculty of Letters, Chiba University, Japan; e-mail: h.yamano@chiba-u.jp)

A purely binocular color system, which integrates inputs from different eyes only when the two eyes are stimulated simultaneously, has been implicated in both binocular color-mixture and adaptation studies. The former studies reported color mixture or color fusion between different colors presented dichoptically. The latter studies reported adaptation effects specific to simultaneous binocular stimulation with the same colors presented binocularly (eg, Shimono et al, 2009 *Vision Research* **49** 202–210). This study explored the relationship between the binocular color systems implicated in different conditions by investigating the adaptation effect of a binocularly fused color. Comparison was made in the adaptation effect between the simultaneous and alternating adaptation conditions. Under the simultaneous condition, red and green stimuli of 18 cd/m² were presented simultaneously to the left and right eyes, respectively, whereas under the alternating condition the same color stimuli were presented alternately to the same eyes. Color stimuli were flickered at 5 Hz to facilitate binocular fusion. We found almost identical adaptation effects under the simultaneous and alternating conditions, although observers reported stable color fusion under the simultaneous condition. These findings suggest that binocular color processing does not always produce differential adaptation effects.

◆ **Predicting categorical colour perception in successive colour constancy**

- 24 J Roca¹, C A Parraga², M Vanrell² (¹Computer Vision Center, Spain; ²Computer Vision Centre/Computer Science Dept, Universitat Autònoma de Barcelona, Spain; e-mail: jroca@cvc.uab.cat)

Colour constancy is a perceptual mechanism that seeks to keep the colour of objects relatively stable under an illumination shift. Experiments have shown that its effects depend on the number of colours present in the scene. We studied categorical colour changes under different adaptation states, in particular, whether the colour categories seen under a chromatically neutral illuminant are the same after a shift in the chromaticity of the illumination. To do this, we developed the chromatic setting paradigm (2011 *Journal of Vision* **11** 349), which is as an extension of achromatic setting to colour categories. The paradigm exploits the ability of subjects to reliably reproduce the most representative examples of each category, adjusting multiple test patches embedded in a coloured Mondrian. Our experiments were run on a CRT monitor (inside a dark room) under various simulated illuminants and restricting the number of colours of the Mondrian background to three, thus weakening the adaptation effect. Our results show a change in the colour categories present before (under neutral illumination) and after adaptation (under coloured illuminants) with a tendency for adapted colours to be less saturated than before adaptation. This behaviour was predicted by a simple affine matrix model, adjusted to the chromatic setting results.

◆ **Conformity of dichromate colour samples to colorimetry, colour appearance, and psychophysics**

- 25 S Fomins¹, M Ozolinsh², K Luse² (¹Institute of Solid State Physics, UL, Latvia; ²University of Latvia, Latvia; e-mail: kaiva.luse@gmail.com)

Following the characterization of printers colour reproduction, candidate samples corresponding to deuteranopy and protanopy confusion lines were printed with inkjet and photographic technology. Samples saturation changed from neutral gray to fully saturated colours with slight variations along to dichromate confusion lines. The task of colour deficient subjects was to estimate the samples for neutrality or presence of chroma under standard fluorescent (daylight, cool white fluorescent, TL84) and incandescent light sources. Samples spectral reflectance was measured and colorimetric values calculated for mentioned light sources according to ASTM 308 standard with appropriate colour matching functions. Change of illumination source produced pronounced effect on colour and neutral samples preferences of colour deficient subjects. We compared psychophysical results to the colorimetric changes due to illumination. Alternatively colour appearance models were applied to check for conformity of colorimetric values to psychophysical results. Our results showed good agreement between psychophysical evaluation of dichromate colour vision persons and colour appearance models. To model the performance of modern solid state illumination colour appearance for warm and cool LED lights was calculated.

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◆ **High-level color adaptation for familiar objects**

26 T López Hernan Perez, C C Carbon, V Hesslinger (Otto Friedrich Universität Bamberg, Germany; e-mail: terelh87@hotmail.com)

High-level aftereffects have mainly been researched in the domains of face and object perception to date: Exceeding mere short-term perceptual changes they also affect mental representations, eg of highly familiar faces for which sustained aftereffects lasting several days have been revealed (Carbon and Ditye, 2012 *Frontiers in Perception Science* 3 1–6). With regard to color perception aftereffects are part of the classical research canon—but only on a low-vision level. To investigate higher-level aftereffects, ie the impact of adaptation on the mental representation of colors, we used highly familiar logos with very distinct, unambiguous color layouts like the yellow Deutsche Post emblem and the red Coca-Cola signet. Aftereffects were triggered by massive exposure to versions of these logos that had been generated by altering the hue 90 degrees (clockwise direction) away from the original one as defined by the HSB (Hue-Saturation-Brightness) color system. To ensure continuous attention participants were asked to indicate the respective orientation of these adaptors (rotated left/ upright/ rotated right). Results showed clear adaptation effects concerning the colors of the employed logos demonstrating high flexibility of the mechanism of color representation, which implicates an extension of high-level aftereffects to the domain of color perception.

◆ **The speed of adaptation as a function of eccentricity and fields luminances adaptation**

27 A H Gloriani¹, B M Matesanz¹, I Arranz¹, C de La Rosa¹, L Issolio², J A Menéndez³, A Galindo⁴, S Mar¹, J A Aparicio¹ (¹Departamento de Física Teórica, Atómica y óptica, Universidad de Valladolid, Spain; ²Universidad Nacional de Tucumán, Argentina; ³Departamento de Estadística e Investigación Operativa, Universidad de Valladolid, Spain; ⁴Servicio de Oftalmología, Hospital General Río Carrión, Spain; e-mail: gloriani@opt.uva.es)

There is a growing interest in studying mesopic since in this range rods and cones are simultaneously active. It has been suggested that rods cone interactions could be responsible for alterations in temporal and spatial visual response. By employing a two-channel Maxwellian view optical system we measured thresholds luminance at a steady adapting field (LA) and a transient adapting field (SOA 300), considering retinal eccentricities between 0° and 15°, and adaptation fields from 0.06 to 100 cd m⁻². We determined the speed of adaptation as the ratio between the steady and transient thresholds. We found very different functional behaviors with eccentricity for adaptation to mesopic and photopic ranges. While at mesopic levels speed increases from fovea to parafovea and decreases to peripheral retina, for photopic fields speed increases monotonically with eccentricity until 15°. We suggest that this behavior is explained by the different rod and cone distributions and its interaction. Physiology of peripheral cones could be responsible of the increase in the speed with increasing eccentricity but, at lower luminances, rod intrusion could be responsible of the velocity decrease in the peripheral retina.

◆ **Steady-state visual-evoked potential adaptation to faces is invariant to orientation, viewpoint and emotions**

28 P Vakli, K Németh, M Zimmer, G Kovács (Budapest University of Technology and Economics Dept of Cognitive Science, Hungary; e-mail: gkovacs@cogsci.bme.hu)

Stimulation of the visual system at a given frequency evokes an oscillatory electrical brain response—the steady-state visual-evoked potential (SSVEP). A recent study has shown that the repetition of the same face results in the habituation of the SSVEP responses compared to a condition in which faces of different identities are presented (Rossion and Boremanse, 2011 *Journal of Vision* 11 1–21). In the present study, our goal was to investigate whether this habituation indeed reflects the recalibration of a neural population engaged in identity-specific processing. First, we could replicate previous findings of SSVEP adaptation: we found greater SSVEP amplitudes for different than for same identity faces over several right hemisphere posterior electrode sites at the stimulation frequency (4 Hz). Further, the SSVEP magnitudes did not differ between these conditions when the faces were presented upside-down, similarly to previous findings. We also observed response habituation when the same identity face was repeated while the 2D orientation or 3D viewpoint, facial expression or the shape of the internal facial features of that face changed continuously. Our results imply the adaptation of a cortical site responsible for the identity-specific representation of faces, independently of orientation, viewpoint and facial expression.

◆ **Investigating face identity perception using event-related steady-state visual evoked potentials**

29 J Liu-Shuang¹, A M Norcia², B Rossion¹ (¹Catholic University of Louvain, Belgium; ²Stanford, USA; e-mail: liu.joan.s@gmail.com)

The perceptual mechanisms underlying humans' ability to individualise faces remain unclear. Here we extend to an event-related mode the recent application of steady-state visual evoked potentials (SSVEP) to study face identity processing (Rossion and Boremanse, 2011 *Journal of Vision*). We recorded 128-channel EEG in 18 observers presented with 60-second sequences of face stimuli shown at a constant frequency of 6Hz. A "base face identity" (A) was repeated throughout each sequence with face size randomly varying at every cycle. Different identities were introduced at fixed intervals (every 4 stimuli, or $6\text{Hz}/5 = 1.2\text{Hz}$), resulting in the following sequence structure: AAAABAAAAC... To ensure that signal at 1.2Hz truly reflected high-level perception of identity, we manipulated orientation (upright vs inverted, experiment 1) and contrast (normal contrast vs contrast reversal, experiment 2). Both experiments showed marked increases of EEG amplitude at 1.2Hz and its harmonics ($2F = 2.4\text{Hz}$, $3F = 3.6\text{Hz}$...), with peak values in the right occipito-temporal channels around P8. While the basic 6Hz response was large for inverted and contrast-reversed faces, responses at 1.2Hz and its harmonics—corresponding to identity change detection—were minimal in these conditions. These observations validate the event-related SSVEP approach and prompt its use in further investigations of face identity perception in different human populations.

◆ **Adaptation to grating motion reduces pattern selectivity in area MT**

30 A Kohn, C A Patterson, S C Wissig (Albert Einstein College of Medicine, USA; e-mail: adam.kohn@einstein.yu.edu)

Neuronal responses and perception are altered by adaptation, the recent history of stimulation. The hierarchical organization of the visual system, in which higher areas perform computations on input from lower areas, gives rise to distinct issues for understanding how adaptation affects visual processing. While the effects of adaptation have been seen across multiple levels of processing, little is known about how adapted input from early cortex affects computations in downstream networks. To address this issue, we recorded neuronal responses in area MT of macaque monkeys, where some neurons integrate the motion signals represented in early cortex. We find that prolonged exposure to a drifting grating, previously shown to adapt neurons in early cortex, reduces pattern selectivity in MT. A feedforward model demonstrates that changes in MT pattern selectivity can be produced by altering V1 input. Both in the model and in our data, the way in which adaptation alters MT tuning for grating motion is predictive of how pattern selectivity is affected. Grating adaptation also reduces perceived coherence of bi-stable plaids. Our findings suggest computations in higher cortical areas can be disrupted by the altered representation of low level visual features after adaptation.

◆ **Spatial specificity and inheritance of adaptation in the human visual system**

31 S Harrison, J Larsson (Royal Holloway, University of London, UK; e-mail: sarah.harrison@rhul.ac.uk)

Stimulus-selective adaptation to simple visual features such as orientation and motion direction has been observed in multiple human visual cortical areas. It is unclear to what extent this adaptation is simply inherited from V1, or whether it reflects local adaptation in extrastriate visual cortex. We used fMRI to measure the spatial specificity of orientation- and direction-selective adaptation to identify the origin of adaptation to these features. If adaptation originated in V1, we would have expected the spatial specificity of stimulus-selective adaptation to match the extent of V1 receptive fields, whereas adaptation in higher extrastriate areas with much larger receptive fields would have predicted the spatial specificity of adaptation to be correspondingly larger. Consistent with single-unit studies in macaque visual cortex, we found that nearly all of the adaptation in extrastriate visual cortex could be explained by simple downstream inheritance of V1 adaptation. For orientation-selective adaptation, there was no evidence of additional adaptation beyond V1. However, the data suggested that some proportion of direction-selective adaptation may originate in motion-responsive dorsal stream areas (MT, V3A, and V7). Interestingly our results indicated that orientation-selective adaptation, but not direction-selective adaptation, is strongly influenced by suppressive surround effects in V1.

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◆ **Number adaptation does not alter BOLD signal in V1**

- 32 E Castaldi¹, D Aagten-Murphy¹, M Tosetti², D Burr¹, M C Morrone³ (¹Dipartimento di Psicologia, Università degli studi di Firenze, Italy; ²Istituto Scientifico Stella Maris, Calambrone, Pisa, Italy; ³Dipartimento di Fisiologia, Università di Pisa, Italy; e-mail: concetta@in.cnr.it)

Psychophysical studies suggest that the perception of numerosity is a basic sensory attribute which is susceptible to adaptation. Previous neuroimaging studies have reported fMRI habituation signals in the intra-parietal sulcus (IPS). However, it is not clear if this result reflects the adaptation of the primary visual area. We developed a novel adaptation paradigm, wherein rapid adapting and testing stimuli can be separated by more than 20 seconds, producing strong psychophysical adaptation to number. This procedure is ideally suited to measuring BOLD adaptation with rapid event related design. Indeed it allows for temporal dissociation between activity evoked by the adaptation and test stimuli. In spite of psychophysical evidence for adaptation occurring, we did not observe any significant BOLD signal change in V1 demonstrating that the effect is not due to density. We did, however, find clear changes in BOLD activity in area IPS.

◆ **Visuomotor tracking: Minimizing visual error does not rely on visual error alone**

- 33 L Van Dam, D Li, M Ernst (Universität Bielefeld, Germany; e-mail: loes.van_dam@uni-bielefeld.de)

When tracking visual targets with our visible hand or a cursor, vision is the only modality that provides a direct error signal between target and cursor positions. To align cursor and target we should therefore primarily rely on visual error. However, target and cursor represent different aspects of the task: we actively control the cursor but not the target. We investigated whether sudden visual spatial discrepancies between cursor and target are treated differently depending on the respective reliabilities of the target and cursor position signals, and which of the two caused the error. By moving a stylus on a graphics tablet, participants tracked moving visual targets. In different conditions the relative reliability of target and cursor was manipulated, keeping the reliability of the visual error signal constant. If the tracking mechanism is simply minimizing the visual error, participants should adapt equally quickly to sudden changes regardless of whether the position of target or cursor was changed. Interestingly, the results show a clear difference in adaptation rate between the conditions. Partially, this can be explained by considering proprioceptive information about the movement of the hand. Our results furthermore suggest there may be differences in processing visual information for cursor and target.

◆ **Size adaptation affects the perceived size and the BOLD activation of area V1**

- 34 A Pooresmaeili¹, R Arrighi², M C Morrone³ (¹IRCCS Fondazione Stella Maris, Italy; ²Consiglio Nazionale delle Ricerche (CNR), Italy; ³Consiglio Nazionale delle Ricerche (CNR), IRCCS Fondazione Stella Maris, Italy; e-mail: concetta@in.cnr.it)

Most perceptual properties can be affected by adaptation. In this study we show that prolonged viewing of a large, peripherally displayed stimulus causes smaller test stimulus presented to the same region to be perceived smaller than its actual size, while adaptation to a smaller stimulus causes the test to appear larger. Adaptation to a stimulus of the same size did not change perceived size. To explore the neural correlates of this effect, we measured the spatial extent of the BOLD activation of the retinotopically defined primary visual cortex (area V1). We found that the size of the activated V1 surface decreased after adaptation to a larger stimulus and increased when preceded by a smaller adapter, by comparable amounts to those observed psychophysically. Adaptation to a stimulus with the same size did not change the size of the activated V1 surface. The pattern of V1 activation closely matched the behavioral effects of size adaptation. These results corroborate recent findings showing that activity in V1 reflects the perceived size of a stimulus even when this perception is illusory and non-veridical.

◆ **Motion-direction specificity for adaptation-induced duration compression depends on temporal frequency**

- 35 A Bruno, E Ng, A Johnston (Dept of Cognitive, Perceptual and Brain Sciences, University College London, UK; e-mail: a.bruno@ucl.ac.uk)

Adapting to a 20 Hz oscillating grating reduces the apparent duration of a 10 Hz drifting grating subsequently displayed in the same location relative to a stimulus displayed in an unadapted position. The effect is orientation-independent, as it remains for an adaptor rotated 90° relative to the tests (Johnston, Arnold and Nishida, 2006 *Current Biology* **16**(5) 472–479). However, at 3 Hz, duration compression follows adaptation only when adaptor and test drift in the same direction with no compression when they drift in opposite directions (Curran and Benton, 2012 *Cognition* **122**(2) 252–257). Here we explore

direction dependence for a wider range of temporal frequencies (3–18 Hz). We first measured perceived temporal frequency for the same stimuli after adaptation and we used these estimates to match the apparent rate of the adapted and unadapted tests in the duration task. We found that, while at 3 Hz the effect of adaptation in the opposite direction on apparent duration is indeed marginal, at higher frequencies the amount of duration compression becomes substantial. These results indicate that there are probably two mechanisms at work here: one sensitive to orientation and motion direction at low temporal frequencies, and a direction-independent mechanism at higher frequencies.

◆ **Craniotopic adaptation-based changes to perceived event-duration are not accompanied by changes in perceived onset or offset of stimulus**

36 T Vercillo¹, D Pittelli², G M Cicchini³, D Burr⁴ (¹Robotics, Brain and Cognitive Sciences Dept, Istituto Italiano di Tecnologia, Italy; ²University of Florence, Italy; ³Institute of Neuroscience, CNR-Pisa, Pisa, Italy; ⁴Departement of Psychology, University of Florence, Italy; e-mail: dave@in.cnr.it)

Although perceived time is thought to be a supramodal perceptual dimension, recent evidence suggests that perception of duration is subserved by specialized mechanisms selective for stimulus position. A series of studies has shown that adaptation to temporal intervals occurs both in retinotopic as well as craniotopic coordinates. In the current study we reinforce the evidence for craniotopic adaptation by showing that craniotopic adapters of different speeds have opposite effects on perception of duration: adaptation at 20 Hz causes the duration of a 600 ms, 10 Hz test to be underestimated, while a 5 Hz craniotopic adapter causes overestimation of the duration of the 10 Hz test. The difference in perceived duration after separate high- and low-frequency adaptation was 85 ms, consistent across subjects. To control for attention and salience we measured (with an acoustic temporal-order judgment) the perceived onset and offset of the visual test stimulus, and found that neither were affected by adaptation. The results reinforce evidence for craniotopic adaption-induced mechanisms of event duration, and further reinforce suggestions that event duration is measured by different mechanisms than those that measure event onset and offset.

POSTERS: AGEING AND DEVELOPMENT

◆ **Visual spatiotemporal processing in the elderly**

37 M Kunchulia¹, K S Pilz², K Parkosadze³, M H Herzog⁴ (¹Agricultural University of Georgia, Institute of Cognitive Neurosciences, Georgia; ²School of Psychology, University of Aberdeen, Scotland, UK; ³Laboratory of Vision Physiology, Beritashvili Center of Experimental Biomedicine, Tbilisi, Georgia; ⁴Laboratory of Psychophysics, Brain Mind Institute, School of Life Sciences, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland; e-mail: marina.kunchulia@gmail.com)

We used backward masking paradigm to investigate the effects of aging on visual spatiotemporal processing. First, thirty-three older ($M = 65.3$ years) and ten younger adults ($M = 24.3$ years) had to indicate the offset direction of a vernier that was masked by a 5- or 25-element grating. We replicated results from our previous study (Roinishvili et al, 2011 *Vision Research* **51**(4) 417–23) and found stronger masking effects in older compared to younger adults. Interestingly, stimulus onset asynchronies between target and mask were significantly longer in older adults whose individually determined vernier durations were above 30msec compared to older adults with vernier durations below or equal to 30msec. Second, we investigated effects of aging on visual spatiotemporal processing using two different masks with either a spatial or a temporal inhomogeneity. Older adults with vernier durations that were similar to young controls were sensitive to temporal and spatial inhomogeneities in the mask indicating fast and spatially intact processing. However, older adults whose individually determined vernier durations were significantly longer than those of younger adults were not as sensitive to temporal and spatial inhomogeneities in the mask, indicating that small spatio-temporal details are filtered out, which is highly likely due to blurred vision.

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◆ **Changes of beta-band power reveal attentional deficits in visual performance of elderly subjects**

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Older adults (65–85 years) show attentional deficits as compared to young (18–30 years) (Madden, 2007 *Current Directions in Psychological Science* **16** 70–74). As increase of beta-band EEG activity was previously related to attentional modulation in the visual system (Wróbel, 2000 *Acta Neurobiologiae Experimentalis* **60** 247–260), we searched for deficits in beta power in elderly subjects performing delayed attentional task with spatial differentiation between target visual stimuli. Two groups of older subjects were characterized by behavioral responses. High Performers did not differ from Younger subjects and showed increased beta activity in occipito-parietal cortex prior to proper behavioral responses. In contrast, Low Performers expressed lower activation in beta band during anticipatory period preceding appearance of target stimulus. In the second group performance and beta activity were significantly lower at the short (3–5 s) and the longest (11 s) periods of stimulus anticipation. We have thus confirmed that attentional deficits in a group of elderly subjects might result from lower activation in beta band at parieto-occipital cortex and that they correlate with disturbed mechanisms of alertness and sustained attention. In addition, we observed that the reduced level of behavioral performance is significantly related with decrease of gamma power in parieto-occipital cluster of EEG sources.

◆ **Early susceptibility to visual illusions after treatment for early-onset blindness**

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P Sinha, T Gandhi, A Kalia, G Chatterjee (MIT, USA; e-mail: psinha@mit.edu)

The dominant account for many visual illusions is based on experience-driven development of sensitivity to certain visual cues. The Ponzo illusion, for instance, where two identical lines placed on a background of converging stripes appear to be of different lengths, is believed to arise from our learned association of 2D perspective cues with the distances they represent in the 3D world. While this explanation appears reasonable, it lacks direct experimental validation. To contrast it against an account that dispenses with the need for visual experience, we have to determine whether the susceptibility to the illusion is present immediately after birth. However, eliciting reliable responses from newborns is fraught with operational difficulties and studies with older infants are incapable of resolving this issue. Our work with children who gain sight after extended early-onset blindness (as part of Project Prakash) provides a potential way forward. We find that the newly sighted children, ranging in age from 8 through 17 years, exhibit susceptibility to several illusions (including Ponzo, Müller-Lyer and simultaneous brightness contrast) immediately after the onset of sight. This finding has implications not only for the likely explanations of these illusions, but more generally, for the nature-nurture argument as it relates to some key aspects of visual processing.

◆ **Consuming dietary flavonoids found in cocoa and berries improves performance on tests of visual function**

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D T Field, M Muggeo, C Saunders, C Williams, L Butler (University of Reading, UK; e-mail: d.t.field@reading.ac.uk)

There is a growing interest in the health benefits of a class of phytochemicals called flavonoids, found in particularly high concentrations in berry fruits and cocoa. Flavonoids are beneficial for the blood supply to the eye and the brain, have neuroprotective effects, and it has been suggested that they influence visual signal transduction in photoreceptors by accelerating rhodopsin regeneration. We therefore performed experiments to determine whether flavonoid supplementation improves performance on measures of visual system function, and have found improvements in the contrast sensitivity of young adults (Field et al, 2011 *Physiology and Behavior* **103**(3–4) 255–260) as well as older adults. In young adults cognitive test performance also improved, but this was not the case for older adults. In the older adult study we measured acuity, and unlike contrast sensitivity this was not influenced by supplementation. Our most recent experiment detected effects of supplementation on accommodation of the lens and convergence of the eyes in young adults, and provided an indication that improved function at low light levels potentially underlies our earlier contrast sensitivity findings. Several hypotheses compete to explain these observations, including enhanced blood supply to the eye/retina, improved attention during tasks, and intervention of flavonoids in the rhodopsin cycle.

◆ **Effect of color and word cues on the following color discrimination task in the elderly**

41 S Ohtsuka¹, M Takeichi², T Seno³ (¹Saitama Institute of Technology, Japan; ²Kokushikan University, Japan; ³Kyushu University, Japan; e-mail: satoko@sit.ac.jp)

We have recently reported that exposure to color and/or color-word cue interferes with later color discrimination task in young people (Ohtsuka and Seno, 2011). The interference was largest when the word was presented in conflicting color. In this study we examined the performance in the elderly. Old people, 60 years of age or more, were recruited as participants. In experimental trials they were asked to decide and respond as quickly and as accurately as possible whether the target was red or green. There were cue types of color, color word, congruent colored word, and conflict colored word besides a control. Cue duration was 150 ms with SOAs of 200 and 1,200 ms. As compared with the young people, the old generally responded slower as expected. The response was especially slower in the word cues irrespective of presentation color, unlike the young people showed it in the color cues. It appears that the elderly have greater difficulty in inhibiting word processing than color processing. Also the old participants' response was not promoted by the congruent cue. The elderly can be confounded by the multiplicity of information itself rather than the discrepancy among them.

◆ **The rapid peripheral motion contrast threshold (RPMCT) test: preliminary validation of a 2 minute screening test for older driver competency**

42 H Woods-Fry¹, S Henderson², S Gagnon¹, C A Collin¹ (¹School of Psychology, University of Ottawa, Canada; ²Transportation Safety Board of Canada, Canada; e-mail: heather_woods595@hotmail.com)

Older drivers have an increased rate of automobile crashes per kilometer driven, likely due in part to age-related declines in motion perception. Our research group has developed the Peripheral Motion Contrast Threshold (PMCT) test as a measure of peripheral motion sensitivity. Results on this test correlate highly with indicators of driving performance in older individuals. However, the duration of the PMCT makes it impractical as a screening tool. Therefore, we developed the RPMCT task as a quicker alternative. Here, we compared the tests to determine if they yield similar results. Participants were 30 undergraduate students, assessed with both tasks. The PMCT presents participants with Gabors (0.4 cpd, 13.75°/s drift) at one of four locations 15° from fixation, and uses method of limits to measure contrast threshold. This takes approximately 10 minutes. RPMCT presents the same stimuli positioned 15° to either side of fixation, and uses a 2AFC variation on the Bekey Method. It takes approximately 2 minutes. Results show a strong positive correlation between PMCT and RPMCT measurements, thus validating the quicker test. Ultimately, we aim to develop the RPMCT into part of a screening battery for distinguishing safe drivers from unsafe ones.

◆ **Does age impact on eye-movement patterns and perceptual biases during face processing?**

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Using chimeric faces (where the left and right side differ on a specific dimension such as gender) it has consistently been found that perceptual and attentional biases are left lateralized. This is considered to reflect the right hemisphere's dominance in face processing. Theories of aging, however, predict that the right hemisphere becomes less dominant in older age (Park and Reuter-Lorenz, 2009 *Annual Review of Psychology* **60** 173–196), thus reducing left lateral biases in older compared with younger adults. We used eye-tracking to quantify lateral bias differences between older (60+ years), and younger (18–30 years) adults in a chimeric gender judgment task. Our findings revealed that both groups displayed a left perceptual bias, basing most of their gender decisions on the left side; initial saccades were also leftward. Additionally, fixations were longer and more frequent when gender judgments were based on the left compared with the right side—but no between groups lateral bias differences were revealed. The response times of the older adults were, however, significantly slower than the younger group, potentially indicating underlying performance differences. As these results clearly contrast with accepted theories of aging, potential reasons for this and avenues for future research will be discussed.

◆ **Age-related differences in the perception of expressive movements in point-light displays of dancers**

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An increasing amount of research investigates the perception of body movements by employing point-light displays. In a recent study, Sevdalis and Keller (2011 *Psychological Research* **75** 423–

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434) demonstrated that observers are able to distinguish between expressive and inexpressive dance movements in such kinematic displays. Motivated by these findings, and by inconsistent effects of age on the perception of biological motion (see Troje, Faubert and Legault, 2012 *i-Perception* 3 104–111), we asked younger and older participants ($N=40$; age range: 20–60) to rate whether point-light videos of dance movements, performed with two musical pieces and tempi, represent an expressive or inexpressive dance style. All participants reported familiarity with the musical and dance styles that were presented. Younger and older participants were able to discriminate with greater than chance accuracy between the two different levels of expressivity in dance, although responses were—irrespective of age—biased towards ‘expressive’ ratings. Interestingly, younger adults showed significantly higher accuracy in detecting expressive intensity in dance compared to the older age group. Kinematic analyses are underway to investigate this age effect by examining which motion cues are meaningful for the discrimination ability of the younger and older participants.

◆ **A projection method for investigating indoor lighting needs of visually impaired people:**
45 **validation**

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Objectives: Optimisation of indoor lighting is an integral part of the rehabilitation of visually impaired people. A well illuminated environment is beneficial for making optimal use of residual vision capabilities. Visibility of the indoor environment can be improved by using general improvements like an optimal illumination level, creating illumination homogeneity, shielding off disturbing luminances and increasing useful contrasts. The range in which the illumination level is optimal and acceptable however, tends to be very dependent on the individual person. Cornelissen et al (1995) use a realistic test room (the LightLab) where the subject has to detect and recognize different every day objects under increasing illumination conditions. This test provides boundaries for an optimal illumination level and functions also as a way of experiencing the benefits of optimal lighting for a patient and his/her relatives. We adapted this test to make it more flexible for our purposes: (i) allowing for retesting by easier scene changing, (ii) availability of the test at more locations in our organization at limited cost, (iii) easier luminance control of specific objects within a scene, (iv) allowing for specific scenes for different groups, eg adults, children and mentally disabled people. We validated the new test for implementation in the rehabilitation practice. Methods: Investigated is the use of video projection with separate grey filters for precise luminance adjustment. Normal subjects were tested under increasing luminances. The normal subjects wore additional grey filter goggles. The stimuli consist of real life living room scenes. A validation of the projection (2D) lightlab is done by testing a group of visual impaired people both in the new setup and in the conventional (3D) LightLab Also the results are compared with clinical measurements such as visual acuity and contrast sensitivity. Results and conclusions: We report on technical comparison between 2D and 3D setup, and present preliminary test results of the validation setup. The results show that the 2D setup can be used for clinical measurements in the rehabilitation program of visually impaired people.

◆ **Ageing effects on visual field asymmetries within magno and parvocellular pathways**

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Available evidence regarding anisotropies of nasal/temporal and superior/inferior retinal function have been previously documented based on anatomical and psychophysical measurements. We aimed to explore these asymmetries in normal ageing using contrast sensitivity (CS) tests that tackle magno- and parvocellular pathways. Monocular CS was measured using Frequency-Doubling Technology, a magnocellular biased test (FDT: 211 eyes; 34.76 ± 1.25 yrs, 10:83) and Intermediate Spatial Frequency perimetry (ISF: 191; 35.95 ± 1.26 yrs, 7:72). FDT stimuli were vertically sinusoidal gratings of 0.25 cycles per degree (cpd) undergoing 25 Hz counterphase flicker, and 3.5 cpd and 0 Hz for ISF. Temporal and/or superior patterns of disadvantage were found per age groups, using FDT: <20 yrs ($T < N$, $p < 0.001$); (20;30(($S < I$, $p = 0.009$); (30;40(($T < N$, $p < 0.001$; $S < I$, $p = 0.025$). For older age groups no patterns of asymmetry were found. ISF showed a pattern of nasal and/or superior disadvantage: <20, (20;30(and (30;40(($N < T$, $p = 0.001$); (40;50(($N < T$, $p = 0.03$; $S < I$, $p = 0.002$); (50;60(, ns; (60;(, ($S < I$ ($p < 0.001$). The

main finding was that different retinal based anisotropies occur across multiple visual pathways and are affected by ageing, especially for magno-biased perimetry (lost in older groups). Nasal/temporal asymmetry was opposite between magno- and parvocellular visual channels and both maintain a superior hemifield disadvantage.

◆ **Age-related changes of contrast discrimination threshold and contrast response**

47 K Okajima (Yokohama National University, Japan; e-mail: okajima@ynu.ac.jp)

Contrast sensitivity at threshold level declines with age. However, it remains unclear the quantitative age-related differences of contrast response arising from contrast stimuli. The reasons why those differences have not been clarified may be that contrast sensitivity depends on contrast intensity and it is difficult to directly compare contrast responses of different observers. Therefore, we conducted a contrast discrimination experiment using achromatic Gabor patches (3.24 x 3.24 degrees, average luminance: 47.5 cd m⁻²) with several kinds of spatial frequency (1, 2, 4, 8, 16 cpd) and contrast intensity C (0, 5, 10, 15, 20, 40, 60, 80%) in young (23–27 yrs) and elderly (65–75 yrs) participants, and estimated contrast response functions from the data. In a trial, two Gabor patches with different contrast intensities C and C+dC were presented on a CRT-display and observers responded whether the two patches are the same or not. Experimental results show that contrast discrimination threshold depends on contrast intensity C and spatial frequency as well as age. We developed expressions for contrast sensitivity and contrast response as functions of age, spatial frequency and contrast intensity, and finally achieved to create simulated images seen by the elderly for young observers by using the calculated formulae.

◆ **Age-related changes in saccadic suppression**

48 S Aydin, V Manahilov, N C Strang (Glasgow Caledonian University, UK; e-mail: senay.aydin@gcu.ac.uk)

Saccades are rapid and frequent gaze shifts that scan visual environments and foveate objects of interest. Saccadic eye movements cause smearing and distort retinal images. However, these are not perceived due to saccadic suppression, which reduces visual sensitivity during saccadic onset. We investigated age-related changes in saccadic suppression of contrast sensitivity for discriminating the polarity (darker or brighter compared to the mean screen luminance) of a large horizontal bar (a half cycle of a cosine luminance profile with a width of 5 deg) during horizontal saccadic eye movements of 7 deg size. Young subjects (mean age 26±5.37 years, n= 6) exhibited significant reduction of contrast sensitivity, compared to that without saccades, which started 50 ms before the saccadic onset, approached a maximum (220%) at the saccadic onset and lasted about 100 ms after the onset of the saccades. For older people (mean age 72.6±6.08 years, n= 6), suppression of contrast sensitivity was only 25% during the saccadic onset and approached a maximum (116%) 50 ms after the onset of the saccadic eye movements. The reduced and delayed saccadic suppression in older adults suggest that they may perceive an unstable external world, which could affect their mobility in everyday environments.

◆ **On the relation between face perception and visuo-spatial abilities in normal and pathological aging**

49 D Gandini¹, I Rouleau², S Joubert³ (¹CRIUGM, Canada; ²Institut des sciences cognitives (ISC), Canada; ³CRIUGM—CERNEC, Canada; e-mail: delphine.gandini@criugm.qc.ca)

The aim of this study was twofold: (1) to examine the encoding strategies of face perception in healthy old individuals and patients with Alzheimer disease (AD), and (2) to determine the link between visuo-spatial abilities and face perception in these two populations. To do so, we tested two groups of participants, 20 healthy old subjects (mean age = 77.5 years) and 20 early-AD patients (mean age = 78.8 years), using a face matching task. To study encoding process of faces, we manipulated the inversion effect, referring to the findings that recognition of inverted faces is less accurate and more time-consuming than recognition of upright faces. In a first task, we compared perception of faces versus cars. In a second task, we manipulated distance between face attributes (eg, eyes). Finally, the two groups were assessed with a series of visuo-spatial tests (eg, Benton face, Benton line, VOSP). The results showed that healthy older participants and AD patients did not encode faces in the same way. Moreover, in AD patients, the mean percent errors on matching inverted faces negatively correlated with some measures of visuo-spatial abilities. These results have some implications for the understanding of the effect of AD on face perception.

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◆ **Effect of age perception and lineup procedure on face recognition**

50 J S Song, W H Jung, S Lee (Chungbuk National University, Republic of Korea; e-mail: lsbok@paran.com)

The purpose of this study is to test the effect of age perception on face recognition in simultaneous and sequential condition. Stimulus were pictures of Northern Asian female faces from the diverse age groups. For half of the cases, targets and distractors were from the same age group. For the rest, distractors were from diverse age groups. The results showed that participants recognized face more accurately in the sequential presentation condition. They also responded more accurately when both targets and distractors were from the different age groups. In addition, Also unlike to face perception, same age effect was not found. These results suggest that visual features for age perception are used for face recognition and memory. [This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2010-330-B00312).]

◆ **Changing views: the role of ageing in the matching of unfamiliar faces across dynamic or static changes in viewpoint**

51 C Maguinness, F N Newell (Trinity College Dublin, Ireland; e-mail: fnewell@tcd.ie)

Previous reports, largely based on static images, have suggested that unfamiliar face recognition is worse in older than younger adults. However others report that recognition is best when faces are learned though dynamic rather than static presentations. Furthermore preserving the temporal order in which 'rigid' (eg rotation) face images are presented across viewpoints affects performance (Wallis and Bülthoff, 2001 *Proceedings of the National Academy of Sciences of the USA* **98**(8), 4800–4804). Here, we tested how the recognition of dynamic faces across changes in viewpoint is affected by the ageing process. Younger and older adults learned either a video, or a static sequence of discrete images of a face moving between a frontal and 45° view. Test images were either of a novel extrapolated or interpolated view (ie within the training set) of the face. We found that while face perception in younger adults benefited from multiple static image presentation, perception in older adults benefited from dynamic information during learning when the test face viewpoint was novel. Our results suggest that the integration of multiple static views into a single representation of a face becomes more difficult with ageing and that face perception in older adults may benefit from preserved temporal order of images, particularly when generalising across viewpoints. [Funded by The Innovation Academy, Trinity College Dublin].]

◆ **Near-infrared spectroscopy detects specific inferior-frontal activation during visual memory tasks in elderly**

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The purpose of this study was to examine the hemodynamic response of the inferior-frontal area during recognition tasks using NIRS. A total of 15 young and 15 healthy old adults participated in the present study. Hemodynamic response in the prefrontal cortex was measured using a NIRS system. The recognition task were examined using digit stimuli, verbal stimuli (visual stimuli that allow for verbal-name coding) and nonverbal stimuli (visual stimuli that do not allow for verbal-name coding). During the digit and verbal recognition task, oxygenated hemoglobin concentrations increased and deoxygenated hemoglobin concentrations decreased in old adults. But it is observed different pattern in young adults.

◆ **Global motion perception at low speed is reduced due to increased internal noise and reduced sampling efficiency in young, mid-aged and old observers**

53 L Bogfjellmo¹, P J Bex², H K Falkenberg¹ (¹Buskerud university college, Norway; ²Schepens Eye Research Institute, USA; e-mail: helle.k.falkenberg@hibu.no)

With age there is a reduction in motion perception, and the sensitivity is reduced for slow speeds. We have shown that the reduction in direction discrimination of global motion with age is due to both increased internal noise and reduced sampling efficiency. Using an EN paradigm, this study further explores how speed affects direction discrimination. 64 observers (16–19 years, 40–49 years, and 70–89 years) identified the direction of global motion in a 2AFC task. The 8 degree stimuli consisted of 100 moving band-pass dot elements with of 10% Michelsons contrast moving at 1.5 or 5.6 deg/s. Internal noise and sampling efficiency were estimated from the direction discrimination thresholds as a function of speed and age. Direction discrimination was significantly worse for 1.5 deg/s and in the oldest age group ($p < 0.05$). The reduced sensitivity to slow motion in young and adults is mainly due to further increase in internal noise ($p < 0.05$). For the oldest age group there is also a significant loss in sampling efficiency ($p < 0.05$). The further reduction for speed indicates that speed is processed by two independent

systems tuned to high and low speed, and that the channel for slow speed is more vulnerable to optical and neural age changes.

◆ **The effect of visual field loss on non-foveal visual localisation and pointing precision**

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We investigated the effects of visual field loss on visual localisation judgments and the performance of visually guided hand movements. We tested 10 older adults (61–72 years) and 8 patients with glaucoma (55–76 years). Visual localisation and pointing precision were measured at four locations each at 15 deg eccentricity, with targets (0.5 deg, white dots, 174cd m⁻²) presented on a black background (0.1cd m⁻²). Testing was performed binocularly, to more closely resemble real world functioning and monocularly, to accentuate the effects of visual field loss. For the pointing task, experimental groups did not differ in pointing precision ($p>0.05$), with no effect of binocularity ($p>0.05$). Pointing precision was significantly reduced with reduced visual field sensitivity ($F_{1,132.0}=19.1$, $p<0.001$, $R^2=0.12$). For the visual localisation task, monocular precision reduced with reduced visual field sensitivity ($F_{1,32.21}=11.37$, $p<0.01$). Participants with glaucoma had reduced binocular visual localisation precision compared to controls ($F_{1,18.74}=4.66$, $p=0.04$), but precision did not co-vary with visual field sensitivity ($p>0.05$). In summary, patients with visual field loss have reduced ability to locate objects both for perceptual judgments and visually guided actions. Perimetry provides only a small indication of the degree of this difficulty. Our data indicates that peripheral binocular function may be impaired in people with glaucoma.

◆ **The influence of auditory interference on imitations of observed sequential movements in young and older adults**

55 J Stapleton, F Newell (Trinity College Dublin, Ireland; e-mail: johnstapo@gmail.com)

Recent studies have reported that visuo-spatial memory can be compromised in older adults. As a possible consequence, spatial navigation is more error prone in the older group, particularly under reduced visual conditions. Moreover, we reported that efficient perception in older adults depends more on multisensory than unisensory inputs. We investigated whether visual spatial memory can be enhanced by synchronous, or impaired by asynchronous, auditory cues in older persons. We adopted a reported task in which participants imitated observed linear movements using a stylus (Maryott and Sekuler, 2009 *Psychology and Aging* **24**(2), 476–486). We presented a sequence of 5 visual movements to younger and older participants who were subsequently asked to imitate this sequence on a touchscreen computer. An auditory cue occurred either congruently, or was temporally offset (pre- and post-visual stimulus), with the occurrence of a turn on the visual sequence. We found that older adults are more error prone than younger adults, as reported previously. Also, incongruent auditory cues differentially disrupted imitation performance in the older group. Our findings suggest age-related changes in multisensory influences on spatial memory.

◆ **A comparison of older and younger adult performance for multisensory integration of visual and auditory rate information**

56 A McKendrick¹, C Brooks¹, A Anderson¹, N Roach², P McGraw⁴ (¹The University of Melbourne, Australia; ²The University of Nottingham, UK; e-mail: allisonm@unimelb.edu.au)

This experiment investigated interactions between visual and auditory rate perception in younger (aged 22–32, $n=10$) and older (age 60–75, $n=6$) adults. Observers were required to perform a rate discrimination task for each modality in isolation, and also when conflicting rate information was presented in the other sensory modality. Because auditory rate discrimination is typically more precise than visual rate discrimination, and because differences in low-level sensitivity may exist between older and younger adults in either the visual or auditory domains, rate discrimination performance was measured under conditions of equated auditory and visual sensitivity for each observer. For both groups, when the discrepancy between the visual and auditory rate was small, cues were partially integrated as has been shown previously (Roach et al, 2006 *Proceedings of the Royal Society B* **273** 2159–2168). Under conditions of equated unimodal sensitivity, the degree of cue integration did not differ between older and younger adults. This data suggests that normal aging does not impact on the flexible processes used by the brain to determine whether to integrate or segregate multisensory signals.

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◆ **Spatial-frequency and category-specific deficits in normal aging**

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The objective was to investigate the deficit of spatial frequency (SF) with aging in a categorization task of object, and its relationship with a category-specific deficit. Thirty young and 24 mature adults had to categorize 120 photos of objects (animals/tools) presented for 200 ms in one of three versions: normal, band-pass (1.9–6.7 cpd) and low-pass gaussian-filtered (0–3.8 cpd). Results showed three main effects: a global impairment in precision in the mature group, an overall SF-specific deficit (non-filtered > band-pass > low-pass) and a whole category-specific effect (animals>tools). Moreover, a SF-specific deficit effect with age was found, as the decreased precision for the mature group was restricted to band-pass filtered images. Furthermore, while there was no significant global category-specific effect with aging, the SF-specific deficit with aging interacted with category, as the decreased precision in the old group for the band-pass version was obtained for tools only. This interaction between the SF-specific deficit with aging and the category is discussed according to the relevant SF band for the task and to the structural similarity and dissimilarity of the items within the category. These variables could explain the discrepancy of previous results on category-specific effect in normal aging.

◆ **Words do not automatically activate semantic networks in the brains of already proficiently reading children**

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Prominent “embodiment” theories argue that word meaning is represented in distributed cortical networks overlapping with sensory-motor regions. For example, words should activate the same brain regions as pictures of the objects they describe, and this co-activation should contribute to comprehension. We explored how a cortical category preference for written tool and animal names develops during the initial school-age years while children become proficient readers. Seven- to ten- year-old children and adults performed a one-back basic-level discrimination task with animal and tool pictures or their associated written words in an MRI scanner. Performance was consistent across age. All age groups showed clear differential cortical specialisation for tool and animal pictures. In adults, regions with a preference for tool or animal pictures, most notably the tool-specific left medial temporal gyrus and inferior frontal gyrus, showed similar activation patterns for tool and animal words. Thus, consistent with previous studies, object category representations were elicited merely by presenting the corresponding written word. In contrast, even older children who were proficient readers, showed no co-activation of picture-induced activation on the presentation of tool or animal words, suggesting that automatic activation of semantic tool and animal networks for words emerges after initial acquisition of word comprehension.

◆ **Do delay release the verbal overshadowing effect in child and adult eyewitnesses?**

59 V Vanooteghem, S Brédart, H Dehon (University of Liège, Belgium;
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The verbal overshadowing effect (VO) (eg, Schooler and Engstler-Schooler, 1990 *Cognitive Psychology* 22(1) 36–71) suggests that the fact of generating a verbal description of a previously seen face may impair subsequent performance on a lineup identification task in adults. Previous research has examined whether descriptions also impaired children’s identification abilities but no evidence of VO was found (Memon and Rose, 2002 *Psychology, Crime and Law* 8(3), 229–242). However, the method might not have been appropriate to observe this effect as, for instance, a 24-hour delay between the description and the identification tasks (associated with a release of the VO effect in adults) was used. Hence, in this current experiment, groups of children (7–8, 10–11, 13–14 years old) and adults were presented with a short video and then assigned to a description or a no description condition before the identification task. Participants were also assigned either to a “no delay”, a “24-hour post encoding delay” or a “24-hour post description delay” condition to determine the influence of delay on the VO effect. Results indicated that, compared to the control condition, the description decreased correct identification performance in both children and adults and no release of VO was found with delay.

◆ **The development of speed discrimination abilities**

- 60 C Manning¹, D Aagten-Murphy², L Pellicano¹ (¹Centre for Research in Autism and Education, Institute of Education, UK; ²Dept of Psychology, University of Florence, Italy; e-mail: c.manning@ioe.ac.uk)

The processing of speed is an important part of visual development, allowing children to track and interact with moving objects. Previous work has reported immature speed discrimination thresholds in 5-year-olds (Ahmed et al, 2005 *Vision Research* **45** 2129–2135) but no study has investigated the developmental trajectory of speed discrimination abilities or precisely when these abilities become adult-like. Here, we measured speed discrimination thresholds in 5-, 7-, 9-, 11-year-olds and adults, using random dot stimuli with two different reference speeds (slow: 1.5 deg s⁻¹; fast: 6 deg s⁻¹). Sensitivity for both reference speeds improved exponentially with age and, at all ages, participants were more sensitive to the faster reference speed. However, sensitivity to slow speeds followed a more protracted developmental trajectory than that for faster speeds. Furthermore, sensitivity to the faster reference speed reached adult-like levels by 11 years, whereas sensitivity to the slow reference speed was not yet adult-like by this age. Different developmental trajectories may reflect distinct systems for processing fast and slow speeds (eg, Edwards, Badcock and Smith, 1998 *Vision Research* **38**(11) 1573–1580). The reasonably late development of speed processing abilities may be due to inherent limits in the integration of neuronal responses in motion-sensitive areas in early childhood.

◆ **The development of global motion sensitivity in children**

- 61 F Corbett, J Wattam-Bell (University College London, UK; e-mail: fleur.corbett.10@ucl.ac.uk)

Global translational motion sensitivity matures around five years after global form sensitivity (Gunn et al, 2002 *Neuroreport* **13** 843–847). The mechanism and development of global motion integration is not yet understood. This study investigated whether the extended maturation period is present in other motion types. Bertone and Faubert reported that sensitivity to global radial and rotational motion was reduced relative to global translational motion sensitivity (Bertone and Faubert, 2003 *Vision Research* **43** 2591–2601). However, Blake and Aiba reported no significant differences between global translational, rotational or radial motion sensitivity (Blake and Aiba, 1998 *Japanese Psychological Research* **40** 19–30). Form and motion sensitivity was measured in eighty-three 6–12 year olds with stimuli that required global spatial and temporal integration of signal elements. Participants had to detect coherent signal patches presented either side of a central fixation cross. Across the sample, form sensitivity was consistently higher than motion sensitivity. Sensitivity to rotational and radial motion was tightly coupled across the developmental trajectory and improved with age. However, sensitivity to translational motion was significantly poorer than radial or rotational motion sensitivity and did not correlate with age. This persistently low sensitivity to global translational motion suggests disparate developmental trajectories and requires further examination.

◆ **Coherent motion and coherent form perception in developmental dyslexia**

- 62 S Giovagnoli, S Magri, R Bolzani, M Benassi (Università di Bologna, Facoltà di Psicologia, Italy; e-mail: sara.giovagnoli@unibo.it)

The role of visual perception in Developmental Dyslexia (DD) is still controversial. Although the Magnocellular theory of DD has been widely criticized, it is still unclear if the deficit in motion perception is specific for the Magnocellular system or if it is connected to a general difficulty in discriminating signal to noise. The aim of this study is to investigate dorsal and ventral pathways in different conditions of noise in a population of DD. Seventeen DD and forty-three typically developed (TD) children (age 7–12 years) participated in the study. All the subjects performed the Motion coherence test and the Form coherence test. In the motion coherence test the ability in discriminating the direction of luminance coherent moving dots in different levels of noise is reported. The Form test measures the ability in form recognition in different condition of noise. The MANOVA showed that DD differed from TD both in the Motion and in the Form coherence tests. Moreover, these differences are significant only in intermediate noise conditions. These results are in accordance with the noise exclusion theory of DD and added important information about the DD deficit in discriminating signal to noise.

◆ **Developmental processes in audiovisual object recognition and object location**

- 63 M M Barrett, F N Newell (Trinity College Dublin, Ireland; e-mail: barretm2@tcd.ie)

This study investigated whether performance in recognising and locating target objects benefited from a cross-modal cue. We also examined developmental processes in these tasks by testing across different age groups. Using the same set of stimuli, participants conducted either an object recognition task (respond

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to two predefined animals out of four), or an object location task (respond to two predefined locations out of four). Target stimuli were presented either by vision alone, audition alone, or bimodally. Bimodal cues were either congruent or incongruent. Our results revealed that reaction time to target stimuli in both tasks benefited from the presence of a congruent cross-modal cue, relative to incongruent or unisensory conditions. In the younger adult group, the effect was strongest for response times although the same pattern was found for accuracy in the object location task but not for the recognition task. Following recent studies on multisensory integration in children (eg Brandwein, 2010; Gori, 2008), we then tested performance in children (ie 8–14 year olds) using the same task. Although overall performance was affected by age, our findings suggest interesting parallels in the benefit of congruent, cross-modal cues between children and adults, for both object recognition and location tasks.

◆ **Early development of dynamic shape perception on the slit viewing condition**

64 T Imura¹, N Shirai² (¹Niigata University of International and Information Studies, Japan; ²Niigata University, Japan; e-mail: imuratomoko@gmail.com)

Developmental processes of global shape and motion perceptions in infancy are relatively well described. For instance previous studies suggest that the sensitivity to global shape develops relatively slower than that to global motion (cf Atkinson, 2000). In this study, we examined the ability to integrate both global information, motion and shape, in infancy. We adopted the slit viewing paradigm to investigate the ability to integrate spatio-temporal information in infants aged from three- to twelve-month-olds. An experimental session consisted of six familiarization trials and two test trials. Each infant was exposed to a line drawing of object moving back and forth behind a slit (0.7 or 1.2 deg in width) in familiarization trials, and was tested to a pair of line drawings in test trials. One of the two drawings in a test trial was a novel one, and the other was a drawing which previously appeared behind the slit in familiarization trials. The findings suggest that the infants aged 5-months and over looked longer at novel drawings than familiar ones in the test trials. This implies that the infants recognized whole shape of the line drawing under the slit viewing condition.

POSTERS: fMRI

◆ **Representation of egomotion in the brain and its relation to vection**

65 M Uesaki, H Ashida (Kyoto University, Graduate School of Letters, Dept of Psychology, Japan; e-mail: m.uesaki@googlemail.com)

Representation and processing of visual cues to egomotion have been associated with visual areas MT+, V6; multimodal areas ventral intra-parietal area (VIP), cingulate sulcus visual area (CSv), precuneus (Pc); and vestibular areas parieto-insular vestibular cortex (PIVC), putative area 2v (p2v) (Cardin and Smith, 2010 *Cerebral Cortex* **20** 1964–1973). This study assessed whether optic flow is encoded differently depending on the magnitude of vection, using 3T fMRI. Two types of optic-flow stimulus were presented in blocks: One consisted of dots moving through spiral space at a speed scaled to eccentricity, whilst the other consisted of dots moving through the same spiral space at a constant speed. The former optic flow was consistent with egomotion in terms of the speed of the dots and therefore induced stronger vection. Contrarily, the latter was inconsistent with egomotion, and induced weaker or no vection. All seven areas responded well to optic flow. Bilateral areas CSv, VIP, p2v and right Pc responded more strongly to the scaled optic flow than to the unscaled. Results suggest that when the speed gradient of visual stimulation is consistent with egomotion, activation in the multimodal and vestibular areas is greater, which may reflect vection.

◆ **Making sense of noisy visual input: interactions between lateral and medial ventral brain regions associated with object recognition**

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The ventral visual pathway has been implicated in conscious recognition of objects. Earlier studies have pointed towards the lateral section of the ventral cortex as an essential region for object recognition, but recent work also implies a function for more medial sections. The interactions between these different sections within the ventral pathway are not well understood. Data were collected in an fMRI study

where thirteen subjects recognized images of objects and animals that were gradually revealed from noise (Meppelink et al, 2009 *Brain* **132**(11), 2980–2993). Here we investigated effective connectivity within the ventral pathway with dynamic causal modeling (DCM) and Bayesian model selection. We defined bilateral intrinsic connections in a network comprising the primary visual cortex (V1), lingual gyrus (LG) and the lateral occipital cortex (LO), and studied the modulatory effect of object recognition on this network. We found that object recognition modulated both feed-forward connectivity from V1 to LG and LO as well as bilateral connectivity between LG and LO. Our results suggest that object recognition is the result of an interplay between areas in the medial and lateral sections of the ventral stream.

◆ **Processing of relative visual location in the Superior Parietal Lobule (SPL)**

67 L A Inman, D T Field (University of Reading, UK; e-mail: d.t.field@reading.ac.uk)

Data is presented which suggests that part of the SPL is selectively involved in processing relative locations of visual stimuli in the scene, and how these locations change over time. The processing of relative visual locations of surrounding objects is important during self-motion for perceiving one's position in the scene and detecting a course of travel free of collision. The involvement of the identified SPL sub-region in self-motion processing has been identified by previous fMRI studies (Field et al, 2007 *Journal of Neuroscience* **27**(30) 8002–8010; Peuskens et al, 2001 *Journal of Neuroscience* **21**(7) 2451–2461). Here, using fMRI, we show that the same SPL region can be activated by visual stimuli and tasks that do not imply self-motion. The region activates selectively when action depends on processing relative locations of objects. This activation occurs regardless of whether motion accompanies changes of object location, and regardless of whether changes of location are predictable or not, which were two other possible driving forces behind the activation. We thus present the best evidence to date concerning what information is processed in this region and show that its role is more general and not specific to self-motion processing as was previously proposed.

◆ **Action understanding within and outside the motor system**

68 S Petris, A Lingnau (Center for Mind/Brain Sciences, University of Trento, Italy; e-mail: sandra.petris@unitn.it)

The human mirror neuron system (hMNS) has been suggested to play a key role in the process of action understanding by means of a matching mechanism between observed and executed actions (Rizzolatti and Sinigaglia, 2010 *Nature Review Neuroscience* **11**(4) 264–274). Here we aimed to determine to which degree areas outside the hMNS are involved in action understanding. We presented participants with point-light displays depicting human actions and engaged them in tasks that required identifying the goal or the effector that constitutes an action. Our paradigm revealed a stronger blood-oxygen level dependent (BOLD) signal during the Goal in comparison to the Effector Task not only within the hMNS, but also in the middle temporal gyrus (MTG) and the anterior ventrolateral prefrontal cortex (aVLPFC). This effect was modulated by task difficulty, with the MTG being sensitive to the difference between the Goal and the Effector Task only when actions were easy to recognize, whereas aVLPFC and inferior frontal gyrus (IFG) were sensitive to this difference also when the task was difficult. Our results suggest an important role for MTG and aVLPFC in action understanding and thus provide important constraints to the assertion that action understanding is based on a direct matching mechanism.

◆ **Activation of parahippocampal place area when looking at geographic maps: an fMRI study**

69 R Rozovskaya, E Pechenkova (Brain functional MRI group, Radiology Center based on Federal Center of Medicine and Rehabilitation, Russian Federation; e-mail: renata.rozovskaya@gmail.com)

An extensive literature shows that there is an area within parahippocampal gyrus, labeled parahippocampal place area (PPA), which specifically responds to images of natural scenes such as landscapes or cityscapes. Several studies have also demonstrated PPA activation when subjects perform spatial map-related tasks, including mental map rotation and navigation (Lobben et al, 2005 Proceedings of the 22nd International Cartographic Conference). However, it is still unclear whether this area responds to geographic maps or schematic images of real places as such or is recruited by the specific spatial task. In our fMRI study, participants viewed series of maps and scrambled maps presented at the rate of about one image per second while performing one-back task. Each subject also completed a PPA functional localizer (one-back task with images of houses and faces). The ROI analysis revealed significant PPA activation for maps vs scrambled maps at the group level and in 11 out of 16 individual participants.

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Thus, the study has shown PPA activation for geographic maps even in the absence of specific spatial map-related task, supporting the idea that abstract depictions of land regions elicit activation within brain areas involved in natural scene perception. [Research supported by RFBR grant # 10-07-00670-a.]

◆ **Neural bases for individual differences in the experience of time**

70 J Tipples¹, P Johnston², V Brattan² (¹University of Hull, UK; ²University of York, UK;
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How do we perceive time when there is no sensory modality dedicated to time? A dominant idea is that humans possess a pacemaker-accumulator clock that produces a number of pulses that increase with the experienced duration. Here, we test the idea that individual differences in the rate of this device predicts increases in neural activation the areas that subserve time perception. Seventeen participants completed both a control task and temporal bisection task, in a blocked fMRI design. In keeping with previous research we recorded increased activation in a network of regions typically active during time perception including the right caudate, insula, supplementary motor area (SMA) and putamen. Furthermore, in keeping with the idea of a pacemaker-accumulator clock, increases in the rate of the pacemaker clock (as indexed by lower bisection points) were associated with increased activation in specific neural areas (SMA and right-orbitofrontal cortex) that were active during time perception.

◆ **Classification of material properties**

71 E Baumgartner, C B Wiebel, R H A H Jacobs, K R Gegenfurtner (Justus-Liebig-University Gießen, Germany; e-mail: baumgartnerelisabeth@gmail.com)

The representation of different materials has been investigated through brain activation (Hiramatsu et al, 2011 *NeuroImage* 57(2) 482–494) and machine classification (Liu et al, 2010, IEEE CVPR, 239–246). Here we explored whether individual properties of materials could be classified as well. Subjects rated images of materials on different material properties: glossiness, transparency, colourfulness, roughness, hardness, coldness, fragility, naturalness and prettiness. These images were then analyzed according to statistical parameters (Portilla and Simoncelli, 2000, *International Journal of Computer Vision* 40(1), 49–71). We applied a linear multivariate classifier to the image statistics and could successfully discriminate images with high or low ratings. Classification accuracy was between 75% and 96% correct for the different properties. Taking only pixel statistics into account performance was still clearly above chance for several properties. To test whether property information contained in the image statistics would be reflected in brain activation patterns three subjects were scanned with fMRI while viewing material images. A classifier was then applied to the voxel timeseries in ventral visual cortex. Again, we found classification accuracy to be significantly better than chance. These results demonstrate that individual material properties can be classified based both on image statistics and fMRI activation patterns.

◆ **Material categories in the brain**

72 R H A H Jacobs, E Baumgartner, K R Gegenfurtner (Justus-Liebig-University Gießen, Germany; e-mail: richard.jacobs@psychol.uni-giessen.de)

Previous fMRI-studies indicated that the parahippocampal gyrus or medial visual cortex is involved in processing texture and material properties. These studies employed textures on rendered objects. Here, we examined brain activation to close-ups of material surfaces. In the first study, observers classified images of wood, stone, metal, and fabric into these four categories. We classified voxel-patterns occurring in response to the pictures to predict the material category of the picture. Both region-of-interest and whole-brain searchlight analyses confirmed an earlier finding of material coding in the early visual regions, with accuracy declining as one moves anteriorly. In the second study, we used an adaptation paradigm. Participants viewed images of wood, stone, metal, and fabric, presented in blocks with either images of different material categories (no adaptation) or images of different samples from the same material category (material adaptation). As a baseline, blocks with the same material sample were presented (full adaptation). This time, material adaptation effects were found mainly in the parahippocampal gyrus. Our results generalize earlier findings to photographs of textured surfaces. Our findings suggest that the parahippocampal gyrus might not be directly involved in the categorization of material categories.

◆ **Representation of changing heading in Cingulate Sulcus Visual Area (CSv)**

⁷³ M Furlan¹, J Wann¹, A T Smith² (¹Royal Holloway University of London, UK; ²Royal Holloway, UK; e-mail: a.t.smith@rhul.ac.uk)

The processing of optic flow to extract information about heading direction is fundamental for many species. Several human brain regions (MST, VIP, V6, CSv) have been implicated in encoding information about instantaneous heading, but heading typically varies during egomotion and whether change of heading is explicitly encoded is not known. We used multi-voxel pattern analysis (MVPA) to test for the existence of neurons that respond selectively to specific directions of change of heading. We used 3T fMRI to record the BOLD response in seven participants engaged in a demanding central task while optic flow was presented. Changing heading was simulated by smoothly moving the focus of expansion of a dot pattern either from left to right (category 1) or right to left (category 2). Local motion was balanced. Part of the data was used to train a linear support vector machine classifier, the remainder was used for testing. The results showed some evidence for sensitivity to direction of change in MST and VIP. However, the most striking result was in CSv, which was strongly sensitive to direction of heading change, showing up to 90% decoding accuracy. This suggests that area CSv may have a special role in monitoring heading change.

POSTERS: ORGANIZATION, LEARNING, AND ACTION

◆ **Independence between action components in catching revealed by visual uncertainty**

⁷⁴ J Lopez-Moliner (Universitat de Barcelona, Spain; e-mail: j.lopezmoliner@ub.edu)

In interception the timing of the action to catch a ball at the arrival time is controlled through two components: RT (catch initiation) and movement time (MT). Uncertainty of the arrival time could affect either component or both. By showing different parts of the parabolic path of a ball I manipulated the degree of uncertainty of visual estimates of arrival time and studied how this manipulation affects RT and MT. Subjects wearing a data glove had to catch balls in a VR setting. The trajectories were shown in 3 viewing conditions (early, late and full path) and haptic feedback was given in half of the sessions. Regardless of the feedback, the mean RT and its SD were affected by visual uncertainty: more uncertainty led to start closing the hand earlier and with higher variability. When no haptic feedback was provided, there was a RT-MT coupling, in which uncertainty of RT predicted MT duration (slope about 1). However when haptic feedback was given, MT duration was independent of the initiation of the catch. This suggests that unfolding the catch is controlled by the expected sensory consequences, while a threshold based on different visual information triggers the initiation of the catch.

◆ **Temporal dynamics of candidate interpretations during object recognition**

⁷⁵ K Torfs, S Panis, A Bartlema, J Wagemans (University of Leuven [KU Leuven], Belgium; e-mail: johan.wagemans@ppw.kuleuven.be)

We investigated the role of candidate interpretations when people recognize objects, focusing on the contribution of different spatial frequencies in their formation, and the time-windows in which they are most effective. We used a stimulus set consisting of 80 grayscale pictures of objects, and filtered versions with either their low or high spatial frequencies (LSF and HSF, resp.). In a pre-study with long exposures, subjects ($N=105$) were asked to list all potential objects that could have given rise to the LSF pictures. In two priming experiments with short exposures, subjects had to classify the objects as manmade or natural (experiment 1, $N=20$), or to identify them (experiment 2, $N=7$). Survival analysis was used to study the temporal dynamics of candidate interpretations during object recognition. The results showed that the number of candidates generated by the LSFs of the target influences the occurrence of recognition responses, but only when response latency is long, and all candidates belong to the same category as the target. Our results highlight the importance of coarse shape information in the activation of candidate interpretations during object recognition and, more generally, the need to control for the moment of responding by using an appropriate statistical technique.

◆ **Adaptation to temporal delays requires dynamic feedback**

⁷⁶ C de La Malla¹, J Lopez-Moliner¹, E Brenner² (¹Universitat de Barcelona, Spain; ²VU University, Netherlands; e-mail: e.brenner@fbw.vu.nl)

It is known that people can adapt to temporal delays. We here examine what kind of feedback promotes temporal adaptation. We asked participants to hit targets that were moving in different directions at different speeds, and compared performance across sessions in which (a) delayed visual feedback was provided throughout the movement of the hand, (b) participants saw a brief delayed representation of

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their hand as it crossed the target, and finally (c) they were shown the spatial error (knowledge of result) in their performance immediately after each movement. Participants could only correct their on-going movements in the first condition, so performance in the other two relied totally on adapting to the delay. The temporal delay was gradually increased to reach a total of 200ms. The timing of the hand movement with full feedback closely followed the imposed delay. This was also so when participants only saw the last part of the movement. Much less adaptation was found when the positions of the target and hand at the time of the hit were displayed statically after each movement. We conclude that feedback with spatiotemporal structure is necessary for temporal adaptation.

◆ **Objects affords kinematic properties of potential actions**

77 A Richez¹, Y Coello¹, G Olivier² (¹URECA—University Lille Nord de France, France; ²BCL lab, University of Nice Sophia-Antipolis, France; e-mail: richez.aurelien@yahoo.fr)

In this study, we analysed the effect of object affordances on the motor response to intrinsic (colour) property of a visual object. Previous studies have shown that the compatibility between a manual response to an (intrinsic or extrinsic) object property and the action afforded by the object led to a decrease of response time. In the present study, we assessed whether afforded action can also influence the execution of a motor response when processing intrinsic (non-motor) property of a visual target. 32 participants performed a colour discrimination task of black and white chess pieces presented at different distances on a chessboard. Participants had to grasp as quickly as possible either a proximal or a distal switch in response to the colour of the chess piece. We manipulated the compatibility between the action afforded by the target-object and the response required by the perceptual task. Results showed a motor compatibility effect on reaction time, as previously shown, but also on movement time, suggesting that objects afford not only potential actions but also their dynamical properties.

◆ **Can people change their choice of grasping points during the grasping movement?**

78 D Voudouris, J B Smeets, E Brenner (Faculty of Human Movement Sciences, VU University Amsterdam, Netherlands; e-mail: d.voudouris@vu.nl)

To grasp an object, one must select suitable positions on its surface for placing the digits and move the digits to those positions. We know that digits' movements are adjusted if the grasping points move, but do people always stick to their original choice of grasping points or do they readjust them if doing so is beneficial? Subjects grasped a ball or cube that sometimes rotated briefly by a few degrees immediately after movement onset. When the cube rotated, subjects rotated their grip to end with the digits at about the same points on the surface. When the ball rotated, subjects did not change their movement but simply grasped the ball at different points on its surface. Does this mean that people can reconsider the grasping points during the movement, or are the grasping points defined in relation to the overall shape (that does not change when the ball rotates) rather than to the surface texture? We rotated the cube after carefully placing it such that it could be grasped with one of two orthogonal grip orientations. In some trials, subjects switched grip orientations when the cube was rotated. Thus people can strategically alter the grasping points during the movement.

◆ **Visual and visuomotor perceptual learning: two distinct mechanisms**

79 L Grzeczowski¹, F W Mast², M H Herzog¹ (¹Laboratory of Psychophysics, Brain Mind Institute, EPFL, Lausanne, Switzerland; ²Dept of Psychology, University of Bern, Switzerland; e-mail: lukasz.grzeczowski@gmail.com)

We investigated if visual and visuomotor perceptual learning rely on the same underlying mechanisms. Observers trained with line bisection stimuli in which a center line was either closer to a right or left outer line. In the visuomotor learning condition, observers adjusted the center line with the computer mouse to the smallest offset they could perceive. In the visual learning condition, observers indicated in a binary task if the center line was closer to left or right outer line. Learning occurred in both conditions. Interestingly, improvements in either condition did not transfer to the other condition as shown by pre- and post-measurements (ie visuomotor learning did not improve visual performance and visual learning did not improve visuomotor performance). Our results suggest that visual and visuomotor perceptual learning rely on different mechanisms.

◆ **Motor action reduces the temporal asynchrony between two visual but not visuo-tactile changes**

80

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Perceiving a visual object requires binding of its various physical attributes. However, temporal order judgments (TOJ) have revealed temporal asynchronies in the perception of position and colour changes of a visual target. This study analysed the effect of a motor action on these temporal asynchronies. Results showed that in the perceptual condition, colour change must precede (-37.9ms) position change in order to participant perceive a synchronous change. This physical asynchrony nearly vanished when the same changes took place near the end of a manual reaching action executed towards the visual target (-3.3ms). This reduction of asynchrony was however not observed when participants performed TOJ of visual attributes change in the presence of concomitant tactile information (-36 ms) but with no action. The perceptual relative timing between visual changes was also unaffected when the timing was obtained by comparing each visual change to tactile information resulting from motor action (finger-target contact, -33.5ms) or concomitant tactile information (-27.8ms). These results suggest that predictive signals associated to motor actions contribute to reduce the differential delays when processing two visual attributes of a single object, but this effect does not propagate to cross-modal timing.

◆ **Modality differences in rhythm perception of human movement**

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Humans generally discriminate auditory rhythmical sequences better than visual ones. Previous researches focused mainly on laboratory tasks. We extended this domain to a complex motor task. In two experiments, we tested 52 subjects, expert tap dancers and novice people, who were exposed to movies and soundtracks of paddle sequences performed by a tap dance instructor. The fifty percent of the sequences followed an even rhythm, the remaining fifty percent presented a single step with a rhythmical error included in a range between twelve and twenty percent, compared to the even performance (uneven trials). The task of the subjects was to discriminate the rhythm of performances by expressing a dichotomous response: "even" or "uneven". The results evidenced responses superior to the chance level in all the auditory conditions and in the visual condition with errors superior to sixteen percent. The accuracy was constantly better in the auditory conditions, rather than in the visual conditions. Expertise differences emerged only in the auditory condition. These outcomes are consistent with the literature and confirm the elevated sensitivity of the acoustic channel to rhythmical stimuli. These findings suggest that the temporal information of action could be easily inferred by athletes through auditory models.

◆ **How perceptual learning shapes perception**

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C Cappe¹, C Mohr², M Herzog³ (¹EPFL, Switzerland; ²UNIL, Switzerland; ³EPFL SV BMI LPSY, Switzerland; e-mail: celine.cappe@epfl.ch)

Lifelong learning makes experts. Here, we asked the question how every day experience shapes vision through perceptual learning. We tested performance in visual acuity, vernier discrimination, visual backward masking, Gabor contrast detection, and bisection discrimination tasks. When lifelong visual learning leads to generalization on basic skills, we expect strong correlations between tasks. When perceptual learning is specific, we expect no or very little correlations. The latter is indeed what we found in 36 healthy student observers (mean age = 21.1 years). Except for Gabor contrast detection and visual acuity, all other pair wise correlations were non-significant. These results cannot be explained by intra-observer variability because performance within one task was highly reproducible. In summary, our study suggests that everyday experience shapes perception in a very specific manner.

◆ **Perceptual learning can be improved by transcranial random noise stimulation**

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A Fertonani, C Pirulli, C Miniussi (IRCCS Centro San Giovanni di Dio Fatebenefratelli, Italy; e-mail: cornelia.pirulli@cognitiveneuroscience.it)

Perceptual learning is considered a manifestation of neural plasticity in the human brain. We investigated brain plasticity mechanisms in a visual perceptual learning task using non-invasive transcranial electrical stimulation (tES, ie, direct current stimulation tDCS and random noise stimulation tRNS) applied on the visual areas. Our hypothesis is that different types of tES would have varying actions on the nervous system, which would result in different efficacies of neural plasticity modulation. 107 healthy volunteers

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participated in the experiment, assigned to the groups: high-frequency tRNS (hf-tRNS, 100–640 Hz), low-frequency tRNS (lf-tRNS, 0.1–100 Hz), anodal-tDCS (a-tDCS), cathodal-tDCS (c-tDCS) and sham. Furthermore, a control group was stimulated on the vertex (Cz). The analysis showed a learning effect during task execution that was differentially modulated according to the stimulation conditions. Post-hoc comparisons revealed that hf-tRNS significantly improved performance accuracy compared with a-tDCS, c-tDCS, sham and Cz stimulations. Our results confirmed the efficacy of hf-tRNS over the visual cortex in improving behavioral performance and showed its superiority in comparison to others tES. The repeated subthreshold stimulation of tRNS may prevent homeostasis of the system and potentiate task-related neural activity. This result highlights the potential of tRNS and advances our knowledge on neuroplasticity induction approaches.

◆ **Which is the best timing for neuroplasticity induction in a perceptual learning task?**

84 C Pirulli, A Fertonani, C Miniussi (IRCCS Centro San Giovanni di Dio Fatebenefratelli Brescia, Italy; e-mail: cornelia.pirulli@cognitiveneuroscience.it)

Transcranial electrical stimulation (tES) induces changes in the brain activity, leading to alterations in the behavioral tasks performance. Previous studies suggest the importance of timing in the application of the stimulation. We hypothesize that in the visual system the effects of tES (ie, direct current stimulation—tDCS and random noise stimulation—tRNS) are dependent on the state of cerebral activation. Therefore the same type of stimulation, applied in different moments, may have different effects. We applied tRNS and tDCS before (offline) or during (online) a visual perceptual learning task. 106 participants were divided in seven groups: anodal-tDCS (a-tDCS) offline and online, cathodal-tDCS (c-tDCS) offline and online, tRNS offline and online and sham stimulation. Our results confirm that exists an ideal timing of application, depending on the type of stimulation. We observed an improvement of the performance when a-tDCS was applied before the task, whereas with tRNS we had a great improvement in the performance only during the task. Surprisingly an analogous improvement was present after offline c-tDCS. These results are important for the designing of rehabilitation protocols, highlighting which stimulation is better to choose in relation to its timing of application.

◆ **Illusory contours obtained by means of cast shadows**

85 P Bonaiuto ("La Sapienza" University of Rome, Italy; e-mail: paolo.bonaiuto@uniroma1.it)

Among the procedures for obtaining illusory contours there is an original one obtained by depicting appropriately arranged black cast shadows. Various examples have been created by the author and are shown in the article "From Visual Art to Experimental Psychology and Viceversa" (Bonaiuto, 2011, in *Affective Processes, Cognition and Action*, Biasi, Rome, Teseo). The most refined example depicts athletes in a hurdle race (see the figure). The hurdles have been created by means of illusory contours through cast shadows. A black shadow of proportionate length extends from the propelling foot of each athlete and then appears to bend and to outline a barrier at the other end. These barriers are aligned in parallel to form a row of coordinated elements. The shadows appear to systematically bend and to outline the object which appears to be the cause of this bending, that is, the barrier of hurdles. One of the runners appears to be suspended in mid air while jumping over a hurdle, while the others have different positions corresponding to the various moments of their run-up. The drawing also has an autobiographical reference since the author was a regional champion in Italy in the 400-metre hurdles race.

◆ **Anomalous structure from motion from figure-ground**

86 V Froyen, J Feldman, M Singh (Rutgers University, USA; e-mail: vickyf@eden.rutgers.edu)

We present a novel phenomenon involving an interaction between motion contrast and figure-ground. Our displays contain alternating light and dark vertical strips in which random dot textures moved horizontally, in opposite directions in alternating strips. This motion is consistent with a percept of all light strips in front, with the dark strips completing amodally into a single large moving surface in the back; or vice versa. Surprisingly, the strips that are perceived as figural are also perceived as 3D volumes rotating in depth (like rotating cylinders)—despite the fact that dot motion is not consistent with 3D rotation. (All dots within a strip have the same constant velocity; and any strip shown in isolation is perceived as flat.) We found we could easily manipulate which set of strips is perceived as rotating volumes simply by varying known geometric cues to figure and ground. In experiments, we varied convexity, parallelism, symmetry, and proximity. Subjects indicated which colored strips they perceived as rotating. The results nicely tracked these classic figure-ground cues. In our data, convexity was a substantially stronger cue to figure-ground than either symmetry or parallelism. Our results reveal an

interesting interaction between motion contrast and figure-ground, and provide an effective tool for measuring figure-ground perception.

◆ **Rectangle transformations and size bisection**

87 W Gerbino, G Bulgarelli (University of Trieste, Italy; e-mail: gerbino@units.it)

The domain of rectangles can be described with reference to two transformations: the constant ratio transformation (CRT), in which the aspect ratio is invariant over size change while adjacent sides grow at different rates; and the medial axis transformation (MAT), in which the aspect ratio covaries with size while adjacent sides grow at a constant rate. The square is singular inasmuch as the products of CRT and MAT transformations coincide. To obtain evidence of the relative importance of such transformations for shape perception we used data from the bisection of size intervals along CRT vs MAT rectangle continua. Participants were required to adjust a target rectangle until its size appeared intermediate between those of two extreme rectangles (one about three times larger than the other). Surprisingly, bisection errors for CRT continua were inconsistent; while those for MAT continua displayed a regular increase as a function of rectangle elongation (ie, of the amount of discrepancy from the square). As regards the phenomenal shape of rectangles, including the square, the invariant growth of sides seems more important than their invariant ratio.

◆ **Perception of shape in apparent motion displays**

88 A Zharikova¹, S Gepshtein², C van Leeuwen¹ (¹KU Leuven, Belgium; ²The Salk Institute for Biological Studies, USA; e-mail: aleksandra.zharikova@ppw.kuleuven.be)

We studied how the perception of shape depends on spatial and temporal grouping of elements that make up a closed contour. Observers viewed dynamic displays in which several dots were moving, each along a linear or slightly curved trajectory. In one of the frames ("keyframe") the dots formed the target: an oriented shape tilted clockwise or counterclockwise from the vertical. Observers reported the direction of tilt and rated their confidence on a six-point scale. We varied two parameters. First is shape coherence determined by the distance between actual dot locations and the target shape in the keyframe. As coherence decreased the shape became less salient. Second is distance dM between successive dots within their trajectories. The threshold of shape coherence (at 75% correct discrimination) was a function of dM, indicating that salient apparent motion could disrupt perception of shape. We varied the temporal rate of frames in these displays and also measured strength of apparent motion in displays that contained no shape. This way we isolated contributions of two kinds of grouping: spatiotemporal grouping between frames and spatial grouping within keyframe, and thus measured observers' sensitivity to shape separately from their sensitivity to motion.

◆ **Perception of angles between surfaces is biased towards right angles**

89 T Betz, M Maertens (Modeling of Cognitive Processes, Bernstein Center for Computational Neuroscience Berlin and Technische, Germany; e-mail: torsten.betz@bccn-berlin.de)

If 2D perspective projections of two rectangular surfaces joined at various angles, like folded cards, are viewed monocularly, they appear to always enclose a right angle. In addition, surfaces enclosing an acute angle seem to look taller than wide, while surfaces enclosing an obtuse angle look wider than tall. We reasoned that if the perceived angle is used as a visual cue to infer the true size of the projected surface, and the angle is perceived incorrectly, then angle variations should be accompanied by systematic misjudgment of perceived surface size, as predicted by a bias to perceive the enclosed angle as perpendicular. We tested our hypothesis by asking observers to adjust the width of a comparison surface to match the aspect ratio of previously shown test surfaces. Observers monocularly viewed projections of two adjoining surfaces of five different widths and three enclosed angles on a computer-screen. Observers judged object width correctly for the right angle. Object width was systematically underestimated for surfaces enclosing 60° angles and overestimated for surfaces enclosing 120° angles. We conclude that with monocular cues only, observers are biased towards perceiving angles between surfaces as perpendicular, and that this misperception affects how they perceive other stimulus properties.

◆ **Is there a common underlying factor in global vs local biases in perceptual organization?**

90 L De-Wit, S Van de Cruys, L Verhoogen, J Wagemans (University of Leuven, Belgium; e-mail: lee.dewit@ppw.kuleuven.be)

It is becoming evident that people's perceptual abilities vary at an individual level in ways that can be meaningfully related to the neural architecture of the human visual system. Indeed, in the context of

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research on autism, it has been argued that there may exist a continuum of variability with regards to whether people focus on local details or the global whole. This general approach (and Weak Central Coherence in particular), however, is often only tested in the context of one stimulus (eg, embedded figures). This selective use of only one or two visual stimuli in a given study makes it hard to evaluate the general claim that there is such a thing as an underlying bias with regards to perceptual organization. To address this, the current work tests the bias towards more local or global interpretations with 10 different cases of perceptual organization (including Kanizsa figures, amodal completion, Mooney figures, Stuart Anstis's balls and grouping in Multiple Object Tracking). These different cases of perceptual organization were tested on 190 University of Leuven undergraduates and will be compared with a common measure of autistic characteristics in the general population (the Autism Quotient).

◆ **Multisensory interaction in prism adaptation**

91 M Fahle¹, M Bornschlegel¹, G Redding² (¹Bremen University, Germany; ²State University of Illinois, USA; e-mail: mfahle@uni-bremen.de)

Prism adaptation is used to study the plasticity of eye-hand coordination to misalignment of the visual and proprioceptive spatial maps. Misalignment can be resolved by adaptive change in spatial maps of either the eyes or hand or both. In this procedure pacing pointing movements with a rhythmic auditory signal is usually employed to control movement speed, but the role of the auditory signal itself in producing adaptation has not been examined. The present experiment addressed this issue by testing three conditions: (1) exposure pointing was self-paced without an auditory signal, (2) exposure pointing was paced by an auditory signal without synchronization, and (3) exposure pointing was synchronized with the auditory signal. The first condition produced primarily proprioceptive adaptation. The second condition also produced primarily proprioceptive adaptation, but visual adaptation was also present. The third condition produced primarily visual adaptation. Results are discussed in terms of a possible role for the auditory signal: movement synchronization with a rhythmic auditory signal may enable multisensory integration, including auditory spatial information that selects the more reliable proprioceptive signal for movement control. Consequently, detection of the misalignment is localized and realignment occurs in the visual system.

◆ **Assessing near vision function: The Italian version of the Radner Reading Chart**

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Purpose: As visual acuity tests are poor predictors of the real-world functions, performance-based tests, eg, reading speed measurements, can be used to better quantify near visual function. The original German-language Radner Reading Chart emphasizes the principle of highly standardized sentences, ie highly comparable in number and length of words, as well as in difficulty and construction. The aim of this study was to create an Italian version of the Radner Reading Chart. Methods: 41 "sentence optotypes" with comparable structure and lexical and grammatical difficulty were created in Italian language, following the procedure defined by Radner. Sentences were performed in 211 normal, non-presbyopic, native Italian-speaking persons. The most equally matched sentence in terms of reading speed and number of reading errors were selected, to develop 28 short Italian sentences. The reading speed results obtained with the 28 selected short sentences were also compared with the average of two long 4th-grade paragraph (97 and 90 words) under the same conditions. Results: The overall mean reading speed of the tested persons was 189 ± 26 w/min. The 28 sentences more similar as reading time were selected, achieving a coefficient of variation (the relative SD) of 2.2%. The reliability analyses yielded an overall Cronbach's alpha coefficient of 0.98. The correlation between the short sentences and the long paragraph was high ($r = 0.85$, $p < 0.0001$). Conclusions: The Italian Radner Reading Chart is precise (high consistency) and practical (short sentences) and therefore useful for research and clinical practice to simultaneously measure near reading acuity and reading speed.

POSTERS: AFTEREFFECTS

◆ Waving-hand steganography by use of 480-fps LED panel

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Decoding of encrypted image provides fun. This sensation is evoked when unconscious information turns apparent. In this research we aim to propose a new way of displaying information or messages so that watching digital signage will not only receive information but will become an enjoyable experience to viewers. A text is hidden in successive frames so that it is unnoticeable when being displayed on an LED panel with a high frame rate (HFR). This hidden text is decodable by viewing through a waving hand. In order to implement a new technique of providing secret information, we have developed a high-frame-rate LED display. Full-color images are refreshed at 480 frames per second. A secret text was embedded into HFR images and represented at 240 fps. When observations were done without waving hand, only white screen or background image can be seen. Secret message was successfully embedded into the background image. However, the secret message was decoded when waving hand. Decoding of the secret message without any special gear has been successfully realized. Observers can decode the hidden image with naked eye by waving hand in front of their eyes.

◆ Local contextual interactions result in global shape misperception

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When required to discriminate between similar shapes the visual system often sacrifices accuracy of representation while exaggerating difference. Adaptation to a stimulus, often results in properties of subsequently presented stimuli being repelled along identifiable axes. Adaptation to a path deformed from circular by a sinusoidal modulation of radius results in a circle appearing to have modulation in opposite phase. We show that the tilt aftereffect (TAE) can account for this. Deformation is also observed when only the orientations of local elements are modulated. In contrast to the TAE, this modification reduces the perceived angle between the local orientation cues. We show that this effect is consistent with a known illusion with a local cause, the Fraser illusion. Both effects can be accommodated by a population of orientation tuned neuron encoding local orientations as a vector sum of contextually modified activation. It is proposed that shape aftereffects, which can be predicted using a spatially continuous representation of the TAE in a TAE field, might serve to de-correlate the responses of higher level shape analyzers with the Fraser illusion being a consequence of using collinear orientation to bind a disrupted path. These distinct processes can arise from the same neural architecture.

POSTERS: BRIGHTNESS AND LIGHTNESS

◆ Articulation effects of 3D backgrounds in the simultaneous lightness contrast illusion

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Articulation effects can influence the strength of lightness illusions (Gilchrist et al, 1999 *Psychological Review* 4(109) 795–834). We investigated the role of 3D articulated backgrounds in the perception of the simultaneous lightness contrast (SLC) illusion. The 2D articulated version of the SLC illusion was used to construct different 3D displays. They consisted of test squares which were moved out of the backgrounds and three different types of 3D backgrounds: (1) 2D patches (2) cubes (3) balls. The luminance range was 1:230. The 2D articulated version of the SLC illusion and three types of 3D displays were presented using the CAVE system. Twenty five observers (age range 17–30) were tested. The method of constant stimuli was used to measure the illusion strength. The results showed that the illusion strength decreased for all 3D displays relative to the 2D articulated version. There were no significant differences between different types of 3D displays. It seems that articulation effects in the perception of 3D SLC illusion weakly depend on the type of 3D backgrounds. [Supported by RFBR grant 12–07–00146a.]

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◆ **Embedding color perception into a variational framework**

96 E Provenzi, V Caselles (Universitat Pompeu Fabra, Spain; e-mail: edoardo.provenzi@upf.edu)

Color perception is a fascinating research field that is receiving more and more attention due to its intrinsic interdisciplinary nature. In the literature, one can find many different models of color perception that focus on various human visual system properties and try to implement them in distinct ways. We will present a general variational framework to model color perception and show that many existing models (notably the famous Retinex theory) can be embedded in this framework. The energy functionals that we consider are composed by two opposite terms: one that induces a contrast intensification in accordance with Weber-Fechner's law of contrast perception and the other that tries to push the intensity values towards the middle gray. The balance between these opponent actions realizes a perceptually-inspired color correction that strongly reduces the effects of color shifts due to illumination changes and notably enhances under and over-exposed images. Variational principles first appeared in Physics with Fermat's principle and then extended throughout the science, providing, as in the present case, a view from above on complex problems.

◆ **Induced curvature and size change by a series of luminance ramps**

97 M Hudak¹, J Geier² (¹Budapest University of Technology and Economics, Dept of Cognitive Science, HAS-BME Research Group, Hungary; ²Stereo Vision Ltd, Hungary; e-mail: janos@geier.hu)

A geometrical illusion is presented, induced by a series of luminance ramps progressing from black to white back and forth. If this grating is displayed on a grey background, surrounded by two thin lines (1 pixel) at the upper and lower boundaries, the lines appear to be curved, while the grating seems thinner where its luminance is low compared to the line, and thicker, where the contrast is high. The illusion also works when several rows of the gratings and the lines are placed under each other in counterphase, but not, if the rows are not in counterphase. The illusion is strongest when the lines are black or white, and weak in case of grey lines. These laws are entirely the opposite to that of the Café-Wall illusion. Another difference is that while in case of our illusion, one row of luminance ramp is sufficient to elicit the illusory curvature, at least two rows of tiles are necessary in case of the Café-Wall. One common feature is that if the lines are thicker, both illusions cease. If the rows are not separated by lines, the boundary edges themselves are not distorted. The illusion is also elicited by chromatic ramps.

◆ **Is the tremor of an eye involved in the decomposition of a complex image into simpler fragments over time?**

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Although, eye movements have been extensively investigated, functions of the tiny eye movements, known as tremor, and its impact on vision are not understood yet. Generally, a cancellation process of the fading effect, information reduction and hyperacuity phenomenon are associated with eye micromovements. We suggest that eye tremor can be related to the calculations of the brightness gradient along the path of the eye movement. Numerical simulations of tremor and its effect on image formation on the retina were performed in Matlab environment. Taking into account the results of the modelling, we conclude that (i) eye tremor can serve as a way to decompose complex image into time-separated simple segments; such procedure simplifies segmentation process of images that satisfy condition of similarity and continuity, and provides positions of imaginary contours; (ii) moreover, owing to the tremor, edges may be specified with sub-photoreceptor accuracy that should increase the acuity of vision; (iii) further analysis of the complex image may be carried out as a processing of the sequence of feature-like images which are simplified fragments of the complex image. [Postdoctoral fellowship is being funded by European Union Structural Funds project "Postdoctoral Fellowship Implementation in Lithuania".]

◆ **Brightness variation in function of stimulus exposure time**

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Brightness contrast can be the result of an interaction process with the luminance of the immediate surround (local interactions) or a consequence of perceptual organization (global factors). It is already

known that a display with competing local and global factors without exposure time limitations results in a perceived brightness contrast induced by global factors. In this study we used reverse contrast Necker cube type displays with the relative controls. The two experimental stimuli were two medium-gray dashed cubes. The first one, having dark inducer corners, was placed on a light inducer background and the second one, having light inducer corners, was placed on a dark inducer background. The control stimuli were identical to the two experimental displays except that the inducer corners were medium gray. The stimuli were presented for 200, 300, 500 and 1000 ms. We asked observers to match the brightness of the dashed lines of each cube to the brightness of a gray scale. Our results show that the brightness change in function of the exposure time: local factors produced the brightness contrast effect at short stimulus exposure time while at longer exposure time the global factors win the competition and become crucial for brightness perception.

◆ **Effect of stimulus intensity on IRP latency, RT in simple and choice tasks**

100 A Nowik¹, J Moczko², E Marzec³ (¹Dept of Biophysics, Poznan University of Medical Sciences, Poland; ²Dept of Computer Science and Statistics, Poznan University of Medical Sciences, Poland; ³Dept of Bionics and Bioimpedance, Poznan University of Medical Sciences, Poland; e-mail: akiwon@gmail.com)

Van der Molen and Keuss (1979 *Quarterly Journal of Experimental Psychology* **31** 95–102; 1981 *Quarterly Journal of Experimental Psychology* **33** 177–184) reported U-shaped relationship between reaction time (RT) and loudness in difficult tasks requiring choice responses. This effect was replicated by Jaskowski and Włodarczyk (2006 *International Journal of Psychophysiology* **61** 98–112) for ultrabright and large visual stimuli. In the current study, we used ERP to investigate the locus of this paradoxical elongation of RTs for extremely bright and large stimuli. The luminance of stimuli was manipulated. Same we also tested a different group of participants with two disparate auditory tones and a five different loudness conditions, task simple and choice reaction. The RT-luminance relationship was monotonic for simple responses and U-shaped for choice responses. Notably, LRP-R was independent of stimulus intensity for both tasks. S-LRP latency changed with brightness similarly to RTs. These results support Van der Molen and Keuss' proposal that it is the response selection stage that is affected by very strong stimuli. Our study clearly indicates that response selection is influenced by intensity changes irrespective of whether visual or auditory stimuli are used, resulting in a U-shaped relationship between RT and intensity when the task is difficult.

◆ **Filling-in versus multiscale filtering: Measuring the magnitude of induction as a function of the distance from the test/inducing field edge**

101 B Blakeslee, M McCourt (North Dakota State University, USA; e-mail: barbara.blakeslee@ndsu.edu)

Brightness induction predictions for a filling-in versus a multiscale filtering mechanism were tested by comparing them to quadrature-phase motion cancellation and static matching measures of induction magnitude as a function of distance from the test/inducing field edge. Filling-in predicts that brightness information derived from the test/inducing field edge fills-in to produce a homogeneous test field percept. Multiscale filtering, however, predicts that induction magnitude will decrease with distance from the test/inducing field edge. In the motion cancellation experiments the 0.0625 c/d inducing grating was counterphased at a temporal frequency of 1 Hz for test field heights of 30 and 90. A 0.250 quadrature probe grating was added to the test field at various distances from the test/inducing field edge and observers made left/right motion judgments of the induced+quad probe compound. In the static matching experiments subjects made point-by-point matches to test fields of 30, 60, and 90 using a small matching patch. The vertical position of the patch cued the vertical location within the display to be matched. The results of both studies show that the magnitude of induction decreases with increasing distance from the test/inducing field edge. These results are consistent with multiscale filtering but not with a filling-in process.

◆ **Spatial structure of contextual modulation**

102 C Clifford, I Mareschal (University of Sydney, Australia; e-mail: cwgclifford@gmail.com)

Contextual effects are ubiquitous in vision and may reveal fundamental principles of sensory processing. Here, we used a reverse correlation technique to investigate the spatial determinants of contextual modulation in orientation (the Tilt illusion) and lightness (White's Illusion). The surround consisted of windows each revealing one of two opposite inducing stimuli. The borders between windows were defined by the zero-crossings of band-pass filtered noise. Subjects had to make a forced-choice judgment

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on a fixed test stimulus. We were thus able to build up classification images showing which regions of the surround had the greatest influence on the perception of the test. The spatial structure in classification images for the Tilt Illusion showed considerable inter-observer variability. However, comparing each observer's results for horizontal and vertical test orientations revealed a high degree of consistency. This lack of dependence on test orientation argues against accounts of the tilt illusion that place particular reliance on collinear interactions. The classification images for White's Illusion contained structure localized along the flanks of the test bar, indicating that the primary effect on perceived lightness in our experiment is assimilation. However, we cannot rule out at least some additional contribution of contrast with the collinear end regions.

◆ **Switching off brightness induction through induction-reversed images**

103 O Penacchio¹, L Dempere-Marco², X Otazu¹ (¹Computer Vision Center, UAB, Spain; ²Computational Neuroscience Group, UPF, Spain; e-mail: penacchio@cvc.uab.es)

Brightness induction is the modulation of the perceived intensity of an area by the luminance of surrounding areas. Although V1 is traditionally regarded as an area mostly responsive to retinal information, neurophysiological evidence suggests that it may explicitly represent brightness information. In this work, we investigate possible neural mechanisms underlying brightness induction. To this end, we consider the model by Z Li (1999 *Computation and Neural Systems* **10** 187–212) which is constrained by neurophysiological data and focuses on the part of V1 responsible for contextual influences. This model, which has proven to account for phenomena such as contour detection and preattentive segmentation, shares with brightness induction the relevant effect of contextual influences. Importantly, the input to our network model derives from a complete multiscale and multiorientation wavelet decomposition, which makes it possible to recover an image reflecting the perceived luminance and successfully accounts for well known psychophysical effects for both static and dynamic contexts. By further considering inverse problem techniques we define induction-reversed images: given a target image, we build an image whose perceived luminance matches the actual luminance of the original stimulus, thus effectively canceling out brightness induction effects. We suggest that induction-reversed images may help remove undesired perceptual effects and can find potential applications in fields such as radiological image interpretation.

◆ **Effect of relative total area on perceived lightness**

104 H Boyaci¹, M Kobal², E Subasi³ (¹Bilkent University, Turkey; ²Turkish Military Academy, Turkey; ³University of Guelph, Canada; e-mail: hboyaci@bilkent.edu.tr)

In a simple two dimensional (2D) display composed of two uniform contiguous surfaces of different luminances, perceived lightness of the surfaces varies as a function of their relative areas while their luminance remains unchanged. Despite empirical evidence dating back to the first half of the 20th century, there is still no clear explanation for this "area rule" of lightness (Gilchrist and Radonjic, 2009 *Journal of Vision* **9**(9) 13, 1–10). While contiguous surfaces have been used in classical studies, here we investigate the effect using stimuli with non-contiguous light and dark regions. Stimuli were computer generated 2D disks, which varied in relative area of light and dark regions with 9 dark wedges of 11 to 354 degrees. The task was to estimate the lightness of dark wedges by adjusting the luminance of an adjustable patch. In line with classical results, we found that the lightness of the darker region increased with its relative area. In the second experiment we used the same stimulus except now the darker regions were divided into two equal parts. Surprisingly, we found that their lightness is affected by not only their individual areas but also the sum of their areas.

POSTERS: CONSCIOUSNESS

◆ **The effect of visual long-term memory on change detection**

105 M Nishiyama, J Kawaguchi (Naoya University, Japan; e-mail: nishiyama.megumi@c.mbox.nagoya-u.ac.jp)

According to recent studies, relatively detailed visual representations are formed instantly and retained long. However, the relationships between the retained long-term memories and current visual perception and cognition have not been revealed. Therefore, we aimed to investigate the influence of visual long-term memory on change detection accuracy. The experiment consisted of three phases. In a study phase, images containing six meaningless objects were serially presented while participants performed a repetition-detection task. Then, in a change-detection phase, on each trial, pre- and post-change images were presented once with a short interval. Half of the pre-change images were identical to the study phase (studied condition), while the other half were novel (novel condition). In a recognition phase, the

images in the study phase were presented and tested to confirm whether they were retained as visual long-term memory. It was revealed that the change detection was more accurate in the studied condition than in the novel condition, and the visual memory formed in the study phase could be retained after the change detection task. It was suggested that visual long-term memory is robust and the memory is available for use in current visual perception.

◆ **Social influence alters perception**

¹⁰⁶ J Jolij (University of Groningen, Netherlands; e-mail: j.jolij@rug.nl)

In one of the classic studies in psychology, Asch demonstrated that social pressure may lead people to give obviously wrong answers in a perceptual decision task. This effect is typically attributed to a deliberate strategy—people do not like to stand out, and conform to a group response, even though their perception tells them they're wrong. However, is this view correct? In this talk, I will present some data that suggests that social pressure may actually change people's perceptions, as measured with evoked brain potentials. In a visual detection task, we let participants detect faces whilst they were influenced by two confederates. We measured EEG to assess whether any changes in responses were accompanied by changes in perception-related brain activity. We managed to replicate the classic Asch-effect, that is, participants conformed their responses to the confederates. Interestingly, these changes in responses were accompanied by changes in brain activity: false alarms were accompanied by perception-related visual evoked potentials (in particular the N200). This result shows that we do not only see what's out there, or even what we expect or feel—to some extent, we also see what others tell us to see.

◆ **Neural activity in human visual cortex predicts bistable perceptual state durations**

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During motion-induced blindness (MIB), a salient target stimulus disappears from perception for variable periods of time when surrounded by a moving pattern. We recorded the magneto-encephalogram (MEG) to characterize the temporal fine structure of neural activity in visual cortex during MIB. In different sessions, subjects reported target disappearance by either pressing or releasing a button. MEG power over visual cortex in the 9–30 Hz frequency range decreased transiently around target disappearance reports, followed by a sustained suppression within the < 9 Hz and 9–30 Hz ranges. The sign of these power modulations reflected the perceptual reports (target disappearance/reappearance), but not the motor responses (button press/release). The modulations were not confined to the cortical sub-regions processing the target: they were equally strong over both hemispheres, irrespective of the target occurring in one visual hemifield. The same modulations occurred when subjects reported on the physical removal of the target ("replay" condition). Remarkably, the amplitude of the transient modulation predicted the duration of the subsequent disappearance state during MIB, but not replay. We conclude that the modulations reflect a state change throughout visual cortex associated with the perceptual decision, which, in turn, stabilizes the subsequent bistable perceptual state.

◆ **Sensory processing in the absence of conscious awareness improves decision-making**

¹⁰⁸ A Vlassova, J Pearson (University of New South Wales, Australia; e-mail: alyavlassova@gmail.com)

Recently there has been a surge of research aimed at discovering the role of conscious awareness in the context of decision-making. The controversial claim that information can be processed and evaluated in the absence of conscious awareness has been heavily debated in the literature. We address this dispute through a novel paradigm that allows us to control and manipulate both awareness and the decision variables. By presenting dynamic noise patterns binocularly, we were able to suppress random-dot-motion (RDM) stimuli from conscious awareness. RDM stimuli require the gradual accumulation of evidence over time, and therefore provide a useful analogue for the processes underlying naturalistic decision-making. We found that information that was presented outside of awareness was accumulated and used to improve decision accuracy. This improvement was not accompanied by a similar boost to confidence. These results indicate that perceptual and metacognitive awareness is not necessary for evidence to be accumulated and an accurate decision to be made.

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◆ **Relation between electrophysiological correlates of affective conditioning and the discriminability and detectability of stimuli in metacontrast masking**

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P Hintze, M Junghöfer, M Bruchmann (Institute for Biomagnetism and Biosignalanalysis, Germany; e-mail: philipp.hintze@uni-muenster.de)

We introduce a new paradigm combining affective conditioning and metacontrast masking. We study the interplay of the affective value of a stimulus and its visibility by manipulating the latter in several consecutive steps. One of two grating stimuli is combined with an aversive auditory startle in a trace conditioning paradigm. This grating thereby acquires a negative emotional valence while the other remains neutral. Before, during and after conditioning, we obtain metacontrast masking functions of the two gratings by varying the stimulus onset asynchrony (SOA) between target and mask. We observe a strong dissociation between detection and discrimination performance: At short SOAs, subjects reliably perceive the presence of a target stimulus yet fail to identify it. With increasing SOA, the discrimination improves while detection performance deteriorates. These effects were unaffected by conditioning. In a study combining behavioral measurements with simultaneous MEG and EEG recordings, we identify the neural sources of affective perception by means of a current density reconstruction. We thereby determine its dependence on stimulus detection versus stimulus identification.

◆ **Unconscious evaluative conditioning: Attitude change induced by invisible words**

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S Yeh¹, H Lin², S Li¹, M Tsai² (¹Dept of Psychology, National Taiwan University, Taipei, Taiwan; ²Dept of Psychology, Fo Guang University, Ilan, Taiwan; e-mail: suling@ntu.edu.tw)

To what extent can unconscious processing affect the choices of individuals? We have shown previously that invisible words can be processed up to the semantic level. Here, we further demonstrate that through evaluative conditioning, invisible words can also induce attitude change to neutral stimuli. A word (US) and a flag (CS) are paired and presented to one eye, but made invisible by continuous flash suppression to the other eye. The word used was “like” or “dislike”, and the flag chosen from a set of flags given neutral valence in a pre-test. Superimposed on the visible masks were two horizontal lines within which the invisible word-flag pair was embedded. Participants judged the relative length of the two lines and verified the invisibility of the word-flag pair after each trial. After 12 trials of each of 8 US-CS pairing, participants gave their emotional evaluations for each flag. Flags that had been paired with the word “like” were rated as positive valence in the post-test; however, this effect did not exist in the visible (binocularly viewing) condition. The fact that evaluative conditioning occurs for unconsciously (but not consciously) perceived word-flag pairs uncovers a new facet of the nature of consciousness.

◆ **Amygdala response for faces in a patient with cortical blindness**

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A Pegna¹, A Hervais-Adelman¹, L Lore¹, M Del Zotto¹, B de Gelder² (¹University of Geneva, Switzerland; ²Tilburg University, Netherlands; e-mail: alan.pegna@hcuge.ch)

Bilateral destruction of primary visual areas leads to blindness of cortical origin. Here, we report the case of a well-known cortically-blind patient presents affective blindsight. Previous observations had shown that emotional facial expressions gave rise to right amygdala activation. In this follow-up study, we carried out a block-design fMRI procedure in which neutral faces were presented along with other objects (cars, bodies, butterflies and scrambled figures) that could not be reported by the patient. When faces were contrasted with other stimuli both amygdalae were found to be activated. Affective blindsight therefore seems to extend beyond emotional stimuli to include behaviourally-relevant stimuli on a more global scale.

◆ **Dissociation between eye movements and motion perception in bistable motion plaid perception for 1D motion, not 2D motion**

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J Hupé (CerCo, Toulouse University and CNRS, France; e-mail: jean-michel.hupe@cerco.ups-tlse.fr)

Usually eye movements are consistent with the direction of perceived motion. Recently however, it was shown that reflexive eye movements followed the vector average of orthogonal moving gratings presented dichoptically, while subjects perceived only one grating and motion direction (Spering et al, 2011 *Psychological Science* **22** 216–225). When both gratings are presented to both eyes, stimuli are ambiguous plaids that can be perceived either as a coherent pattern moving rigidly or as two gratings sliding over each other. Prolonged observation leads to bistable alternation between coherence and transparency. Even under steady fixation moving plaids can generate small optokinetic nystagmus (OKN) along the directions of both component (1D) and pattern (2D) motion. 1D OKN followed the direction of either one or the other grating, not the vector average (whose direction was the same as 2D motion).

2D OKN were twice more frequent when coherence was reported than when transparency was reported, while 1D OKN were not modulated by perception. These results confirm the possible dissociation between eye movements and motion perception with stimuli presented over long durations, but only for 1D motion, not 2D motion. [Supported by Agence Nationale de Recherche ANR-08-BLAN-0167-01.]

◆ **Co-ordination of voluntary and automatic eye-movements: Accuracy of saccades made during concomitant optokinetic nystagmus**

113 J Harrison, P Sumner, T Freeman (Cardiff University, UK; e-mail: HarrisonJJ@cardiff.ac.uk)

During self-motion, saccades intended to foveate targets of interest must co-occur with eye movements which stabilize the retinal image, such as optokinetic nystagmus (OKN) and the vestibular-ocular reflex (VOR). Despite the close relationship between target-selection and gaze-stabilizing eye movements, they are typically regarded as being fundamentally different, with a sharp distinction drawn between conscious and unconscious motor actions. So how can the voluntary saccadic system effectively accommodate simultaneous reflexive nystagmus? We examined this question by asking observers to make saccades to vertically-flashed targets while executing horizontal OKN. Results showed that saccades were only partially compensated for displacements of the eye due to OKN, with further experiments showing that compensation was improved when the displacement was due to voluntary smooth-pursuit. Furthermore, analysis of the saccade trajectories showed that they became curved in a way consistent with the idea that saccades may be influenced by activation of the OKN system. These findings have implications for our understanding of how voluntary and automatic movements are co-ordinated in the human brain, as well as our understanding of the difficulties an active observer faces in orienting to targets during concomitant self-motion.

◆ **Delusions and the role of beliefs in perceptual inference**

114 P Sterzer¹, M Rothkirch¹, M Sekutowicz¹, H Rössler¹, J Haynes², K Schmack¹ (¹Charité—Universitätsmedizin Berlin, Germany; ²Bernstein Center of Computational Neuroscience Berlin, Germany; e-mail: philipp.sterzer@charite.de)

Delusions are unfounded yet tenacious beliefs and a symptom of psychotic disorder. Varying degrees of delusional ideation are also found in the healthy population. Here, we experimentally tested a neurocognitive model that explains the formation and persistence of delusional beliefs in terms of altered perceptual inference. We performed two behavioral experiments and a functional magnetic resonance imaging experiment in healthy participants to probe the relationship between delusion-proneness and the effect of learned predictions on bistable visual perception using an ambiguous random-dot kinematogram. Behaviorally, delusional ideation was associated with less perceptual stability during intermittent viewing of the ambiguous stimulus but a stronger influence of experimentally induced beliefs on perception. The perceptual effect of beliefs was reflected in fMRI signal patterns in visual cortex, from which biased perception could be decoded using multivoxel pattern analysis. Furthermore, delusional ideation was associated with enhanced functional connectivity between an orbitofrontal region that encoded beliefs and visual cortex. Our results indicate that beliefs can influence the contents of awareness through feedback signals from higher-order brain areas to sensory cortices. In delusion-prone individuals, an enhanced effect of beliefs on sensory processing may sculpt perception into conformity with beliefs, thereby contributing to the tenacious persistence of delusional beliefs.

◆ **What's so special about motion? It's all in the tail!**

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It has been suggested that there is a perceptually explicit predictive signal at the leading edges of movement that summates with low contrast targets. Evidence for this is that sensitivity for low contrast target waveforms at leading edges of high contrast inducing gratings varies with the phasic relationship between the abutting stimuli, but this does not happen at trailing edges of movement (1). While this has been attributed to a predictive signal unique to the leading edges of movement, an alternate possibility is that summation simply involves the abutting waveforms, but this summation is selectively inhibited at trailing edges of motion. We assessed this possibility by examining target sensitivity at leading and trailing edges of motion, and by comparing these measures with those for flickering waveforms. Sensitivity for abutting flickers qualitatively matched sensitivity at leading edges of motion; both were marked by phase dependent summation. Thus what differentiates movement from directionless flicker in this context is that sensitivity at trailing edges displays no evidence of summation. We attribute this to an inhibitory operation, involved in suppressing blur signals that usually result from retinal motion.

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1. Roach McGraw and Johnston (2011) Visual motion induces a forward prediction of spatial pattern. *Current Biology*.

◆ **Timing the Rubber Hand illusion: Owning the rubber hand involves substitution, not addition**

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We assume biological hands connected to our bodies belong to self; objects not so connected do not. In the Rubber Hand Illusion (RHI), however, observing a rubber hand being stroked while the occluded real hand is synchronously stroked engenders a feeling that the rubber hand belongs to self. Our investigation had two foci: assessment of RHI's temporal dimension and of competing hypotheses. The former was motivated by dissatisfaction with other behavioral proxies; the latter, intended to determine whether experiencing a rubber hand as mine (ownership) involves the sense that my real hand has been replaced (disownership), or the sense that one has acquired a supernumerary hand. Participants indicated elapsed time for onset of ownership and disownership by stepping on a pedal. Also, after each trial, a questionnaire containing two sets of items—ownership and disownership (derived from Longo et al, 2008 *Cognition* **107** 978–998)—was administered. By both measures the experience of ownership is revealed to be stronger than that of disownership; however, results also indicate that the stronger the ownership experience, the stronger is the experience of disownership. In short, timing RHI and assessment of the relationship between ownership and disownership suggest that RHI involves substitution, not addition.

◆ **Hearing lips and (not) seeing voices: Audiovisual integration with the suppressed percept**

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In binocular rivalry, sensory input remains the same yet subjective experience fluctuates irremediably between two mutually exclusive representations. We investigated whether a suppressed viseme can still produce the McGurk effect with an auditory input, which would indicate that unconscious lips motion sometimes modulate the perceived phoneme through the well-known multisensory integration mechanism. We used speech stimuli for it involves robust audiovisual interactions at several cortical levels. The perceived phoneme when presenting a synchronous voice saying /aba/ together with rivaling faces saying /aba/ and /aga/ was recorded for the seven McGurk sensitive participants. We found that when the dominant percept was seen with the non-dominant eye, in about 20% of the trials the audiovisual outcome resulted from an integration with the suppressed percept. This integration could either produce or cancel the McGurk effect that was expected with the actually seen viseme. This observation raises serious questions in the fields of speech perception and multisensory binding, suggesting that feature binding might not be a prerequisite to perceptual awareness. Further experiments are being conducted to determine whether the information binding failed within the same modality (color and lips motion) or between the two modalities (lips motion and voice).

◆ **The influence of rotational speed and line width on perceptual reversals of the Lissajous figure**

118 V Weinhhammer, K T L Ludwig, P Sterzer, G Hesselmann (Visual Perception Laboratory, Dept of Psychiatry, Charité, Universitätsmedizin Berlin, Germany; e-mail: veithweinhhammer@gmx.de)

Two superimposed and increasingly phase-shifted sinusoidal functions can induce the percept of an object spontaneously changing its direction of rotation, dubbed the Lissajous figure. Here, we investigated the influence of rotational speed and line width on the perceptual reversals of bistable Lissajous figures. By correcting subjects' response latencies with reaction times from a disambiguated replay condition, we found that perceptual switches occurred most frequently when the waveforms overlapped, ie, at depth symmetric displays. At those critical positions, reversal probabilities linearly increased with speed and line width, which ranged from 2 to 9 seconds per rotation and 0.02° to 0.2° of visual angle, respectively. Thus, switch probabilities were highest for slowly rotating stimuli. Interestingly, switches also tended to occur more often for thicker lines. Perceptual switches of the Lissajous figure demand a reassignment of points from background to foreground, and vice versa, which might be facilitated at depth symmetric stimulus configurations. For slowly turning and thick lined Lissajous patterns, these overlaps last longer, thus increasing switch probability. Our findings fit nicely with the hypothesis that prior experience of

the visual environment prevents observers from randomly switching to the otherwise equally plausible image interpretation (Pastukhov, Vonau, and Braun, 2012 *Journal of Vision* **12**(1) 1–16).

◆ **How subliminal visual input modulates visual short-term memory and imagery**

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The interaction between visual short-term memory (VSTM) and visual perception has recently been the subject of much interest. Here we investigated how incoming perceptual information affects information held in VSTM. Subjects were asked to hold in memory the orientation of a grating; during the delay period, a visual distracter could appeared. The orientation of the distracter ranged from 0 to 40 degrees relative to the orientation of the memory stimulus. In the “subliminal” condition, the distracter was followed by a mask, rendering it invisible; in the “visible” condition, no mask was presented. In both cases, VSTM accuracy was impaired when the distracter orientation differed from the memory orientation by 10 or 40 degrees. No difference was found between the “subliminal” and “visible” conditions. In a second experiment, we investigated the influence of subliminal distracters on visual imagery by asking subjects to judge the subjective vividness of the memory stimulus at the end of each trial. Surprisingly, we found that the subliminal distracters reduced vividness not only when accuracy was impaired (with a memory-distracter difference of 40 deg), but also when the distracter was identical to the memory item and did not reduce accuracy.

◆ **Enforcing double dissociations between measures of priming and awareness (or anything else)**

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When comparing an indirect measure of visual perception with a direct measure of visual awareness, unconscious perception can be demonstrated by establishing an experimental manipulation that leads to opposite effects in the two measures, thus implying that they cannot both be explained by a single source of conscious information. Such a double dissociation, eg between priming and identification of a masked prime, requires none of the restrictive assumptions needed for demonstrating that a masked prime is “invisible” (Schmidt and Vorberg, 2006 *Perception & Psychophysics* **68** 489–504). Here a psychophysical procedure is demonstrated that enforces double dissociations between masked priming and prime visibility by experimentally inducing qualitatively different time-courses of visual masking. Participants respond to a visual targets preceded by masked primes, and the intensity of the mask is systematically coupled to the prime-target SOA so that prime visibility either increases or decreases with SOA. A double dissociation is produced when motor priming effects keep increasing with SOA no matter whether prime visibility increases or decreases. Such “enforced double dissociations” between priming and awareness are demonstrated for response priming and Eriksen paradigms. The technique can be applied to explore possible double dissociations in arbitrary fields under tight experimental control.

◆ **Interocular suppression eliminates the processing of perceptual ambiguity**

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Ambiguous visual stimuli are often used as a unique window on perception and consciousness. It remains unclear, however, whether conscious perception is a necessary prerequisite for the processing of ambiguity. To address this question, we tested whether an ambiguous stimulus, rendered invisible by interocular suppression (continuous flash suppression, CFS), affects the perception of subsequently presented visible ambiguous stimuli. In a 2x2 experimental design, a Necker cube was presented either continuously or intermittently to one eye. CFS masks presented to the other eye were either present or absent. When present in the intermittent Necker cube condition, the CFS masks were shown during the stimulus-off periods. In the continuous condition, CFS masks were shown during the same time intervals as in the intermittent condition while the Necker cube was presented continuously. In this latter condition, the Necker cube was thus constantly present but intermittently suppressed from awareness by CFS. As could be shown by comparing distributions of dominance times, the number of perceptual switches, and the probability of perceptual reappearance of the last dominant percept across conditions,

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perception of the Necker cube remained unaffected by periods of invisible stimulus presentation. This suggests that perceptual ambiguity is not processed during interocular suppression.

◆ **Distinct patterns of spontaneous fluctuations in human visual cortex reflect the rate and duration of bistable perceptual states**

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Models of bistable perceptual phenomena posit spontaneous fluctuations in cortical activity across multiple stages of the visual cortical hierarchy. We used fMRI to link activity fluctuations throughout multiple visual cortical areas to “motion induced blindness” (MIB). MIB is a bistable phenomenon, in which a small salient target spontaneously disappears and reappears when surrounded by a moving mask. fMRI activity during MIB was measured in multiple retinotopic subregions corresponding to target and mask, within V1–V4. We computed a matrix of correlations between the fMRI time series in these sub-regions. We used singular value decomposition to identify spatial patterns of temporal correlations that reflected the dynamics of MIB. This identified all activity fluctuations, irrespective of whether or not these culminated in behavioral reports of MIB target disappearance. The fluctuations associated with MIB disappearance rate were target-specific in V4, but not V1. The fluctuations associated with the duration of MIB states were target-specific in V1, but not V4. These two distinct fluctuation patterns reflect distinct mechanisms contributing to MIB. We propose that the V4 fluctuations reflect competitive interactions that are closely coupled to behavioral report. Conversely, the V1 fluctuations may reflect adaptation dynamics that lay the foundation for target disappearance, decoupled from report.

◆ **Developing continuous flash suppression for moving stimuli**

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Continuous flash suppression (CFS) is a technique to reliably suppress stimuli from visual awareness for extended periods of time (Tsuchiya and Koch, 2005 *Nature Neuroscience* 8(8) 1096–1101). Recently, researchers have begun to explore the properties that make a CFS mask effective. Yang and Blake (2012 *Journal of Vision* 12(3) 8, 1–14) report the importance of the spatial frequency match between the CFS mask and the suppressed stimulus. In this experiment, we present a mask that can effectively render moving stimuli unconscious. We tested the influence of the speed of mask elements on suppression strength. Our data show that the threshold for detecting a moving stimulus is highest when the speed of the individual elements of the mask matches the speed of the suppressed stimulus. The saliency maps for each mask show that there are larger bottom up transients in the classical CFS and faster masks while these prove to be less effective. This highlights that bottom up transients in salience are not as effective as matching the motion properties of the to-be-masked stimuli. These results stress the importance of constructing a CFS mask that matches certain features of the to be suppressed stimulus in order to reliably suppress it from awareness.

◆ **Abrupt color change of a previewed mask reinstates object substitution masking**

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When a briefly presented target is surrounded by a sparse mask whose offset is delayed relative to the target offset, its identification is impaired compared to when both have common offset. This is a type of backward masking, called object substitution masking (OSM). Recent studies have reported mask preview effect, in which OSM is largely attenuated by mask preview. We investigated whether and how abrupt change in the color of a previewed mask affects mask preview effect. The basic effect that mask preview attenuates OSM was replicated. Abruptly changing the mask color at the target onset disrupted mask preview effect, that is, OSM was reinstated. In terms of the role of surface features in establishment and maintenance of object representations, we propose that a large color change allows the previewed mask to recompute with the target.

◆ **Top-down mechanisms and conscious visual experience**

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In a previous study the effects of practice on a detection-task with contrast-polarity-cues were analyzed. The results showed evidence for distinct mechanisms underlying each target-condition (present-versus-absent), suggesting the general operation of center-surround-mechanisms with an additional involvement

of top-down influences in the target-present-condition only. The role played by these feedback signals appears to be that of further inhibiting background elements and thereby enhancing the figure-ground processing. Here, the aim is to understand whether such top-down mechanisms are related to conscious perception. Ten participants rated their confidence regarding the presence-absence of the target in a four-point-scale. Using a perceptual-learning paradigm in combination with backward-masking, the results show that masking prevents improvement in both the objective (accuracy) and subjective (confidence rate) measures in the target-present condition, but leaves unchanged the learning effects in the target-absent condition, suggesting the involvement of feedback-loops in the enhancement of both detection accuracy and conscious awareness of the target. A dissociation found between the objective and subjective measures at the beginning of learning in the target-absent condition demonstrates that vision may guide behavior in the absence of conscious experience, as reported by several studies, further suggesting that feed-forward mechanisms alone are not sufficient to promote conscious experience.

◆ **A direct model of indirect perception: the spread mind model**

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One of the main arguments against direct perception and externalism by and large is the alleged evidence in favour of not veridical perception. In fact, it is commonly held that there are many cases of indirect perception in which the external object is missing as it happens in dreams or illusions. The subject perceives something which seems to be not real. If this belief true, it would indeed be possible to have phenomenal visual experience without any corresponding external phenomenon. Contrary to such widespread view, here I will sketch a physical model of direct perception, dubbed the spread mind, that—by means of simple examples offered by optics such as mirror, transparent glasses, caleydoscopes—may endorse all alleged cases of indirect or not veridical perception (Manzotti 2006, 2011a, 2011b). I will review the relevant literature on indirect perception (afterimages, phosphenes in the congenitally blind, synaesthesia, migraine with aura, phantom limb) to show that alternative interpretation of data are available (Kirshfeld 1999; Brugger, Kollias et al 2000; Cowey and Walsh 2000; Mulleners, Chronicle et al 2001; Lopes da Silva 2003; Nir and Tononi 2009). To recap, I will try to show that all cases of perception might be reinterpreted as cases of direct and veridical perception.

POSTERS: CONTOURS AND CONTRAST

◆ **Global and local factors in the enhanced checkered tilt illusion**

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In the “Enhanced checkered illusion” (Kitaoka, 2001 *Nikkei Science* **31**, 22–23) a horizontal line separating adjacent rows of checkerboard tiles appears tilted in presence of local inducers. This effect seems to derive from local contrast polarity relationships between the tiles and the inducers. Local factors, however, do not seem to be able to explain why the tilt seems greater when there are multiple rows of tiles and inducers (ie multiple tilted lines). In two experiments using 2AFC comparisons we studied the role of global factors in this illusion. Experiment 1 showed that the illusory tilt is increasingly stronger when the more lines are present. Results also showed that the tilt decreases as the horizontal distance between the inducers in a row increase. Experiment 2 showed that also the number of inducers in a row influences perceived tilt, which is stronger with more inducers. With multiple lines, however, increasing the distance between them seemed to increase the tilt. Overall, our experiments seem to show that purely local models cannot fully account for this illusion, and suggest that it might increase in strength with eccentricity.

◆ **Synergy of orientation, color and spatial frequency in shape detection**

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How features are combined is a basic question of perception research. Combinations of orientation (O) and spatial frequency (F) are special because they are effortlessly perceived in search displays, while combinations of color (C) and O require detailed scrutiny to be found among distracters (Sagi, 1988 *Perception & Psychophysics* **43** 601–603). A possible reason for this is that O and SF are jointly coded on V1, while O and C are encoded at different layers of the hierarchy, suggesting a selective channeling—later integration processing scheme. We measured detection and identification of shapes defined by feature contrast in O, F, C and their combinations. In line with results from search experiments our data show that shapes defined by O+SF are much more salient than shapes defined by O+C. However,

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shapes defined by feature contrast in two spatially overlaid far apart spatial frequency bands (F1+F2) reached the same saliency levels as the O+SF shapes. Further, presenting the two frequency components dichoptically also yielded high shape saliencies at comparable levels. These results indicate that there is strong fusion across different V1 mechanisms. This implies that joint coding at the level of V1 is an unlikely candidate for explaining feature synergy in early shape perception.

◆ **Individual differences in the influence of contours on crowding**

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We examined how crowding (the breakdown of object recognition in the periphery caused by interference from nearby visual structure) depends on the global arrangement of target and flanker elements. Specifically we probed orientation discrimination using a near-vertical target Gabor flanked by two vertical distracter Gabors (one above and one below the target). By applying variable (opposite-sign) horizontal offsets to the flanker positions we arranged elements so that on some trials they formed contours and on others they did not. While flankers generally elevated target orientation discrimination thresholds we observe maximal crowding not when flanker and targets were strictly co-aligned but when a small spatial offset was applied to flanker location, so that contours formed between flanker and target when the target orientation was cued. We also report that observers' orientation judgments are biased with target orientations appearing either attracted or repulsed by the global/contour orientation. A second experiment reveals that the sign of this effect is dependent both on the observer and on eccentricity. We describe a simple model of our results which computes perceived target orientation as a weighted/probabilistic average of target orientation and (a) flanker orientation and (b) contour orientation.

◆ **Visual perception of forms in 5–12 years old children measured by Form Test**

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A new test of coherent form discrimination called Form Test is proposed in order to assess ventral stream functionality. The task consists of shape discrimination among 8 different forms. The form is obtained by a number of white luminance coherent dots presented on a circular black background. Stimuli are presented in 5 levels of spatial coherence by increasing noise dots. Noise dots are non aligned and non coherent luminance dots which disturb shape discrimination. A sample of 163 children (75 females and 88 males, age range: 5–12) is considered. Results show significant differences among coherence levels: the number of correct answers decreases with noise increment. Moreover, the age of children affect the scores: the performance of children in Form Test improves with age. The results confirm that Form Test can be an helpful instrument to measure the ventral stream functionality and shows its sensitivity to the age differences.

◆ **Effects of learning in amodal completion: an EEG study**

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We investigated the influence of learning on amodal completion, using EEG recordings. In a sequential matching task participants had to judge whether a test shape could be the partly occluded shape in a previously presented occlusion pattern. We distinguished between patterns that could evoke multiple perceptually plausible completions (ambiguous occlusion patterns) and patterns that evoke a single perceptually plausible completion (non-ambiguous occlusion patterns). Participants were tested before and after a learning task in which they had to learn and memorize the less plausible completions. In an earlier behavioural experiment we found learning effects only for ambiguous occlusion patterns. With regard to the current EEG experiment we analyzed ERPs elicited by the test shapes. Before the learning task, the test shapes elicited a P3 complex with comparable mean amplitudes and a maximum over Cz for both sets. For the anomalous shapes following non-ambiguous occlusion patterns no significant enhancement of P3 amplitudes was found due to learning, whereas for the ambiguous occlusion patterns a significant enhancement of P3 amplitude was found for the learned shapes only, which is in line with the behavioural data.

◆ **Poggendorff illusion with all-second-order contours**

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The classic Poggendorff illusion is typically drawn with an outline or filled horizontal or vertical rectangle intersected by two diagonal lines. Misperception of alignment between the latter persists when the rectangle is defined by subjective contours interpolated between Kanizsa-style pacmen, or is a borderless area filled with parallel stripes. Recently (Rose and Bressan, 2011 *Perception* **40** ECVF Supplement, 203) we reported that when the diagonals are defined by pacmen, the illusion reverses direction (for acute angles of intersection with the rectangle), for both outline and pacmen-defined rectangles. Here, we study the Poggendorff figure with the rectangle and its diagonals defined by stripe endings. To avoid the first-order luminance cues inherent in previous stimuli, we created a novel display with zero change in mean luminance across the entire display. The illusion was present with normal direction, indicating that the location cues presented by the first order stripe endings cannot be discounted and automatically participate in defining second-order contour locations at a stage preceding that at which the Poggendorff illusion itself is generated. In this respect, second-order contours defined by line endings are not equivalent to contours interpolated between pacmen.

◆ **Sensitivity to the local shape information of natural images**

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We previously showed that the human visual system is exquisitely sensitive to local natural image regularities (Gerhard et al, 2011 *Perception* **40** ECVF Supplement, 18). However, luminance histogram features were a very salient cue. Here we focus instead on sensitivity to the local shape regularities in natural images. Stimuli were textures made of image patches sampled either from natural images or from a natural image model, where observers had to discriminate the two kinds of textures in a forced choice task. We used a variety of natural image models that capture varying degrees of higher-order correlations. We removed salient luminance cues from the textures and measured discriminability of the models from natural images when shape was the only cue. Above chance performance with patches 4x4 pixels in size and larger indicated sensitivity to higher-order natural image correlations associated with shape. A surprising pattern of discriminability also emerged which indicated an advantage of the independent components analysis model in capturing salient shape content, even though it captures less of the overall higher-order correlations than other models tested. We also analyzed the contribution of different principle components to discrimination performance in order to develop a preliminary mechanistic explanation using responses of spatial frequency filter banks.

◆ **The role of motion information in contour integration: new insights**

134 R Bellacosa Marotti, C Casco (Dept of General Psychology, University of Padua, Italy; e-mail: rosilari.bellacosamarotti@studenti.unipd.it)

The present study aimed at investigating the role of motion information in visual contour integration. We used a classical path detection paradigm to measure observers' efficiency at segmenting fragmented straight contours, composed of Gabor micropatterns, embedded in a field of distractor elements. Gabors were either static or moving, always drifting orthogonally to their orientation with constant speed. The elements forming the path varied in number from three to eleven and could be all oriented either parallel ('snakes') or perpendicular to the contour orientation ('ladders'). This way, they could be distinguished from random background on the basis of orientation alone, when static, or on both orientation and motion direction, either fixed or alternated. We compared detectability of paths when static, coherently moving or with their elements drifting in alternated directions. We found that motion facilitates detection of ladders (as previously shown) and also of snakes. The major finding was that alternating motion direction not only abolished motion facilitation but reduced detectability with respect to the static condition. These results suggest that motion has not a purely additive effect on contour detection but actively participates to the process of contour integration, probably throughout a cooperative motion mechanism.

◆ **Inferior superiority: shape discrimination is better in the lower compared to the upper visual field**

135 G Schmidtman, G J Kennedy, H S Orbach, G Löffler (Dept of Vision Science, Glasgow Caledonian University, UK; e-mail: G.Loffler@gcu.ac.uk)

Integration of information along the circumference of contours is an important feature of shape perception in central vision. To determine how shape discrimination and global integration depend on eccentricity

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thresholds for discriminating scaled radial frequency (RF) patterns with 3 or 5 lobes from a circle were determined at various eccentricities (0–10 deg) along the vertical, horizontal and main diagonal meridians. Global integration strength was measured by comparing performance when shape deformation was applied to various fractions of the contour. At 10 deg, sensitivity for all patterns was significantly higher in the lower than the corresponding upper visual field. For RF3, sensitivity in the lower, lower-right and lower-left positions were approximately the same and >50% better than for all other positions. For RF5, the lower periphery (lower, lower right and left) yielded sensitivities that are >2 times higher than the corresponding upper locations. The improvement in sensitivity when deformation was applied to the entire contour compared to a single cycle provides evidence of global pooling with similar strength at all locations. Discrimination of RF patterns is substantially better in the inferior than the superior visual field. The same global pooling strategy, affording the exquisitely high sensitivity to shape discrimination in central vision, also underlies peripheral shape processing.

◆ **Local density differences in perceptual grouping displays**

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Empirical studies on contour integration often focus on the collinearity of neighbouring elements as a grouping cue. During stimulus construction, differences in the relative spacing of contour and background elements are avoided as much as possible because they might serve as an alternate cue to the presence of a contour, invalidating any conclusions with regard to the collinearity (and co-circularity) of neighbouring elements. Avoiding local density differences is a challenging problem, however. We have implemented a number of element positioning procedures and local density metrics in GERT, the Grouping Elements Rendering Toolbox (www.gestaltrevision.be/gert; Demeyer and Machilsen, 2011 *Behavior Research Methods*). Here, we investigated how sensitive human observers are to local density differences in arrays of radial Gabor patches. We present psychophysical data of a 2AFC experiment comparing two element placement methods and three local density metrics. We evaluate how sensitive each metric is to the physical cue, and how the metrics relate to human performance. The results can serve as a guidance for stimulus construction in future studies.

◆ **A convexity bias in peripheral contour integration**

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We present psychophysical evidence for a convexity bias in contour integration with respect to the fixation point. Participants were presented with a circular arc contour, embedded in a field of randomly positioned Gabor elements, and were instructed to respond as fast as possible whether the contour appeared to the left or to the right of the fixation point. Peripherally presented convex contours (ie, contours that curve towards fixation) were detected faster than concave contours (ie, curving away from fixation). We found this effect to be robust across multiple levels of eccentricity. These findings are at odds with the radial bias in visual perception, which predicts better detection for elements oriented parallel to a line through fixation.

◆ **Task differences in snake and ladder perception**

138 K Vancleef, J Wagemans (University of Leuven [KU Leuven], Belgium;
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In contour integration a relevant question is whether snakes and ladders are processed similarly. Higher detection thresholds for ladders indicate this is not the case. However, besides detection, discrimination tasks are widely used and a comparison between snakes and ladders in different tasks is lacking. In this study we investigate task dependency in snake and ladder processing by a direct comparison of tasks while using identical stimuli. Stimuli consisted of elements that are oriented collinear (snakes) or orthogonal (ladders) to the contour path and are surrounded by random oriented background elements. In two 2AFC-tasks, six experienced subjects either detected the contour when presented with a contour in one interval and a completely random stimulus in another, or they discriminated between contours of weaker and stronger curvature. Presentation time was varied in 9 steps between 8 and 492 ms. In general, the differences between snake and ladder processing were more prominent in the discrimination task than in a detection task. This pattern of results could indicate that ladders are processed by second-order mechanisms because more processing time is required especially when a finer shape judgment has to be made.

◆ **Psychophysical indications of recurrent processing in shape perception**

139 J Drewes, G Goren, J H Elder (Centre for Vision Research, York University, Toronto, Canada; e-mail: mail@jandrewes.de)

The human visual system must extract reliable shape information from cluttered visual scenes several times per second, yet the nature of the underlying computation remains poorly understood. Here we probe the temporal dynamics of this process to estimate time constants that might provide clues to the underlying neural circuit. In (Drewes, Goren and Elder, VSS 2012) we demonstrated a temporal window of facilitation in a repetitive-presentation contour grouping and shape discrimination paradigm with noise masking. Discrimination performance peaked at an ISI of 50msec, excluding iconic memory and probability summation as explanations for our findings. Here we report results of two new experiments that shed further light on this phenomenon. In experiment 1, we replaced the first target shape presentation with a spatial cue. Discrimination performance did not exceed that of a single target presentation, demonstrating that facilitation is not the result of exogenous attentional cueing. In experiment 2 we extended the range of ISIs further in time, finding evidence of temporal oscillation in behavioural performance at an average frequency of 21Hz, in agreement with our previous results. These findings suggest the existence of an important feedback loop in the neural circuit underlying the perceptual organization of contours into shape percepts.

◆ **Classification images for detection and discrimination of contours and shapes**

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We investigated the use of local features and global shape information in detection and discrimination of contour shapes. The stimuli were circular or square contours (diameter 1.34 deg; Gaussian profile, width 0.08 deg), or four evenly spaced contour fragments of the same shapes. The fragments located on the corners, on the sides or between the corners and sides. Classification images were measured for the detection of the stimuli and discrimination between the square and circular shapes. The stimuli were masked with Gaussian white noise (rms 0.27) and 1-interval yes/no and discrimination tasks were used. The adaptive Quest procedure kept the thresholds at 75%. The thresholds were lower for whole shapes than for contour fragments. The detection and discrimination thresholds did not depend on the position of fragments. The classification images, both in detection and discrimination tasks, contained significant information only at the location of contours. We did not find evidence of using global shape template with stimuli composed of contour fragments. The results suggest that shape perception does not depend on the location of the visual feature (corners vs sides). Further, it seems that both detection and discrimination of shapes is determined by the local features of the stimulus.

◆ **Black or white? Effects of luminance polarity on target detection and discrimination**

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Textbooks often recommend black text on a white background (vs white on black) to achieve maximum legibility for display users. This recommendation is supported by physiological studies showing that the visual system assigns more resources to processing stimulus elements with positive polarity (dark on light background) than negative polarity (light on dark background—eg Ratliff, Borghuis, Kao, Sterling and Balasubramanian, 2010 *Proceedings of the National Academy of Sciences USA* **107** 17368–17373). Empirical evidence from applied and psychophysical studies, however, is mixed (eg Alexander, Xie and Derlacki, 1993 *Vision Research* **33** 2491–2497; Buchner and Baumgartner, 2007 *Ergonomics* **50** 1036–1063). In a series of target detection and discrimination experiments, we tested the above recommendation. Two different measures of contrast were used to establish equal absolute values of contrast in positive vs negative polarity conditions. Results varied depending on measure of contrast and task: in most cases we found no difference in detection/discrimination rates between the two polarity conditions. If there was an advantage for one condition, it was for the negative one. These results contradict textbook recommendations and predictions from physiological evidence. Alternative explanations are discussed.

◆ **Circle size judgment by psychophysical scaling**

142 M Costa, B V Nagy, A Magalhães (Universidade de Sao Paulo, Brazil; e-mail: costamf@usp.br)

We used the magnitude estimation to obtain the apparent size of circles. Eighty-two subjects with normal or corrected-to-normal visual acuity (mean age = 22 years; SD = 1.4) were tested. The procedure consisted of two gray circles luminance of 40 cd / m², 10 degrees apart from each other. On the left side was the reference circle (visual angle of 1.1 cpd) in which was assigned an arbitrary value of 50.

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The subjects' task was to judge the size of the circles appearing in the right side of the monitor screen assigning the number proportional to the changed size, relative to the reference circle. Seven different sizes (0.6, 0.8, 1.0, 1.1, 1.3, 1.4, 1.5 cpd at 50 cm) between smaller and larger than the reference circle were presented. Our results have shown a high correlation ($R = 0.9987$) between the logs of the stimuli and the subject response. The exponent obtained was 0.71, which indicates that for the judged apparent size of the circle to be 2 times larger or smaller than the reference, we need a change of 3 times of the physical size. In conclusion, we found a no-linear judgment in the apparent size of gray circles in a visually normal population of young adults.

◆ **Developmental processes underlying orientation discrimination during childhood**

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Orientation-selectivity is critical for higher-level visual processes from edge extraction to the perception of natural images. Only a few studies documented the development of orientation discrimination during infancy, and developmental changes during childhood are practically unexplored. The goal of the present study was to chart the development of orientation discrimination during childhood as a function of contrast, spatial frequency, and orientation noise to understand the changes in its underlying mechanisms during development. Stimuli were circular two-dimensional luminance Gaussian noise with a diameter of 5 degrees. The noise was filtered in the Fourier domain with an anisotropic filter. Orientation discrimination thresholds were determined by means of a one-interval forced choice paradigm combined with an adaptive staircase. Participants had to decide whether the grating was tilted to the left or right of vertical. Six-year-olds are about 3.5 times less sensitive than adults at low (1 cpd) and mid (4 cpd) range spatial frequencies and they are 4.6 times less sensitive than adults at higher (12 cpd) spatial frequencies. Eight-year-olds are still less sensitive than adults by a 2-fold, and that equally so for each spatial frequency. Orientation discrimination is adult-like at 10 years of age for all conditions tested, falling within the range of 0.5 to 1.0 degree. Orientation discrimination is contrast invariant in children when tested with low (1 cpd) to mid range (4 cpd) spatial frequencies that have a contrast equal to or greater than 25%. However, thresholds increase by a factor of two for a spatial frequency of 12 cpd presented at a contrast of 25%. The introduction of noise orientation increases discrimination thresholds for each age group, but significantly more so for the 6- and 8-year-old children. Orientation discrimination matures slowly during childhood and it is influenced by spatial frequency and contrast in the developing visual system but not in the mature visual system. Because internal noise explains much of the functional immaturity in children, the main source of developmental variation in orientation discrimination most likely occurs at the initial stages of feature coding.

◆ **Electrophysiological correlates of contrast perception**

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Contrast information, a primary aspect of visual perception, has been usually bound to psychophysical investigation in humans. In the current work we recorded the electroencephalographic activity in healthy participants during a detection and discrimination task where a gabor was presented under six contrast levels. We analyzed how the variation of the contrast modulates the behavioural (ie, accuracy and reaction times) and physiological responses, such as event related potentials (P100, N2pc) and evoked oscillatory activity. Results showed that both behavioural and electrophysiological indices increased with a non-linear trend in relation to the contrast modulation, which increased exponentially through the conditions. While changes in the early visual P100 amplitude were more affected by exogenous stimulation, the late N2pc component varied consistently with the performance, appearing to be predictive of the behaviour. Moreover, the frequency analysis revealed a power increase of specific frequency bands such as theta (4–7Hz) and alpha (8–14Hz) in relation to the contrast variation. No modulation of the high frequencies was observed. On the whole, this study indicates that activity recorded over human visual cortex is related more to the subjects' percept than to the physically presented stimuli.

◆ **Orientation tuning of near and far surround modulation in V1 cells and in human perception**

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We examined the orientation tuning of surround modulation in 5 human observers and in single cell ($n = 106$) responses in V1 of anaesthetized macaques. For each cell a center grating patch was matched to the diameter of the cell's high contrast summation receptive field and optimized for other stimulus parameters; a surround annular grating was presented either near or far from the center grating, and its orientation was varied from optimal to orthogonal. Center and surround stimuli had 75% contrast. In humans, the center grating had a 2 deg diameter, horizontal orientation and 1cpd spatial frequency, and was presented at 6 deg eccentricity. We used a contrast matching task with center and surround grating contrasts of 20% and 40%, respectively. In both single V1 cells and human perception, the modulation arising from the near surround, ie within the reach of monosynaptic intra-areal horizontal connections, was sharply tuned for stimulus orientation. Instead, far surround modulation, ie arising beyond the extent of horizontal connections, was broadly orientation-tuned. Broader tuning of far surround modulation was due to non-optimal stimulus orientations exerting stronger suppression in the far than in the near surround. Our results suggest different orientation-specificities of the circuits underlying near and far surround modulation.

◆ **Searching in the dark—Saccades during scotopic and photopic visual search**

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V C Paulun, A C Schütz, K R Gegenfurtner (Justus-Liebig-Universität Gießen, Germany; e-mail: Vivian.C.Paulun@psychol.uni-giessen.de)

When we search for visual targets in a cluttered background we systematically move our eyes around to bring different regions of the scene into foveal view (Najemnik and Geisler, 2005 *Nature* **434** 387–391). We explored how visual search behavior changes when the fovea is not functional, as is the case in scotopic vision. Five observers searched for Gabor patches ($SD = 0.5^\circ$, 2.5cpd, additionally 6cpd in photopic condition) embedded in a circular background (radius= 8.5°) filled with 1/f noise under scotopic vs photopic viewing conditions. Scotopic contrast thresholds were significantly higher overall with a functional scotoma in the fovea. Low spatial frequency targets were well visible in the periphery under both light levels. We found that in scotopic search individuals made less but longer lasting fixations and targets were located further in the periphery when detected. In both conditions fixations were dense in the upper center of the visual field. Their distribution was more widespread for higher spatial frequency targets in the photopic condition. This indicates that with adequate peripheral visibility observers prefer to make fewer saccades and take more time to fully integrate information over a larger window of attention.

◆ **Perceived speed and uncertainty: Can a Bayesian model of speed perception account for the effects of contrast?**

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K Brooks¹, K Challinor² (¹Macquarie University, Australia; ²UNSW, Australia; e-mail: kevin.brooks@mq.edu.au)

Bayesian models of motion perception propose that human perception of velocity is influenced both by signals from the stimulus and by a prior preference for stationarity. When velocity signals from the stimulus show little uncertainty, the prior has little effect, but as uncertainty is increased the prior exerts a greater influence, causing a more substantial reduction in the magnitude of perceived velocity. This model can successfully account for several illusions of perceived direction (Weiss et al, 2002 *Nature Neuroscience* **5** 598–604) and has been extended to model the well known contrast-induced speed misperception—the phenomenon that low contrast stimuli appear slower than otherwise identical high contrast stimuli (Hürlimann et al *Vision Research* **42** 2253–2257). This model relies upon the assumption that relative to their high contrast equivalents, low contrast stimuli are accompanied by greater uncertainty. We tested this assumption by assessing the relationship between perceived speed and uncertainty over a range of spatial and temporal frequencies (2AFC speed discrimination: SFs 0.25–8.00 c deg s⁻¹; TFs 2–16Hz; speeds 0.25–64.00deg s⁻¹). While perceived speed was indeed reduced at low contrast, we find no evidence of the model's predicted negative relationship between PSEs and JNDs, calling into question its ability to account for contrast induced speed misperceptions.

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◆ **Modelling grating and bandpass natural-scene contrast-discrimination dippers**

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Chirimuuta, Jiwa and Tolhurst (2007, *Perception* **36** ECVS Supplement, 157) presented a V1 multi-channel model of contrast discrimination giving good fits for sinusoidal grating “dippers” but poor ones for natural or 1/f images, and vice-versa. We now report contrast discrimination for 2.67 c deg⁻¹ gratings, compared with photographic or 1/f images bandpassed (1 octave) to the vertical orientation and spatial frequency as the gratings. Gratings were presented as SL (Small Gabor test patch masked by Large grating), SS or LL; in-phase and out-of-phase annular grating masks on S grating test; and a crossed-orientation masking grating (SL). The 2 bandpassed images were configured SL and LL. A V1 model could be fit (3.6 dB2 error per point) to all grating and bandpassed image “dipper” experiments simultaneously, provided the model’s so-called “non-specific” suppression had some orientation specificity. The model needed surround suppression to explain the different shaped “dippers” for S versus L stimuli. Interestingly, surround suppression was still compatible with the finding that annular masking gratings had little effect on thresholds for surrounded S Gabor patches. The model fits were slightly improved by introducing extra features and their parameters to the model, such as adding a “hard threshold” to the sigmoidal contrast-response transducer function.

◆ **Mirror symmetrical visual facilitation elicited by contingent auditory signals**

149 Y Tanaka (Nielsen-Neurofocus, Japan; e-mail: yt249136@gmail.com)

In studying cross-modal interaction between auditory and visual processing, we found the enhanced contrast sensitivity with auditory primed contingent signals. Detection threshold of a Gabor visual target decreased when the 30-msec tone-burst preceded the target (Tanaka et al 2009). Here I modulated stimulus duration (30, 50, 100, 300 ms), temporal frequency, and onset/offset patterns of auditory signals with various auditory-visual onset asynchronies. Threshold decreased with lesser amount (-0.1 log units) when the visual and auditory signals presented simultaneously. Threshold decreased more (-0.2 log units) when the visual target preceded the pip tone by 50ms, which was suppressed strongly and finally disappeared at 200 to 250 ms. Such oscillatory pattern was common across four observers tested with the variation of response frequencies around 9Hz. Facilitation disappeared using different temporal structures between vision and audition with different temporal duration and rising/falling time, suggesting that the cross modal temporal structure is critical to the effect. Since the oscillatory pattern is mirror symmetrical in time, I assume echoing signals traveling back and forth between visual and auditory systems, constructing periodical pattern of facilitation. This suggests the existence of double mirror neuron system between vision and audition mirroring signals each other in a different time.

◆ **Background influence on object detection in natural scenes**

150 J Plantier, S Buffat, C Roumes (IRBA, France; e-mail: justin.plantier@irba.fr)

It is well established that the visual system analyses scenes through a series of spatial-frequency-tuned channels. Scene perception studies suggested that spatial frequencies of an image were analyzed from low to high spatial frequencies (Parker et al, 1992 *Perception* **21**147-160). An alternative hypothesis is that starting with the retina, the earliest firing cells are those with the strongest inputs in term of luminance contrast (Delorme, et al, 1999 *Perception* **28** 128-129). From this hypothesis, the image is decomposed with a multiscale analysis with six bandpass filters, then a local spatial frequency is defined at each point of the image as the spatial frequency carrying the maximum luminance contrast. This analysis is used to characterize the object salience in function of background complexity. Images of natural scenes, and images reconstructed from the local spatial frequency map were briefly displayed (100 ms). In the experiment, the subjects had to detect the presence of a vehicle. The vehicles were positioned at different locations in the visual field. The object was always congruent with the scene context. The tasks performances (percentage of correct detection, response times) depend on the object salience and the background complexity. Results with images based on the local spatial frequency maps were similar to those obtained with initial images.

◆ **The effect of contrast on preference of print size**

151 N Nagai (Miyagi University of Education, Japan; e-mail: nagai@staff.miyakyo-u.ac.jp)

The purpose of this study was to investigate the effect of contrast on preference of print size. Four sighted persons read sentences on the CRT display and adjusted print size as they preferred. There were two display conditions (the POSITIVE condition: black text on white background and the NEGATIVE condition: white text on black background). In each condition, contrast was gradually decreased (95%,

50%, 25%, 10%). In addition, there were two vision conditions (the CLEAR vision condition: normal observation and the CLOUDY vision condition: observation with a diffusion filter). Results showed that, in both vision conditions, mean preferred print sizes were smaller in the NEGATIVE condition. The ratio of preferred print size in NEGATIVE/POSITIVE condition remained almost constant (0.79 to 0.75) at each contrast level in the CLEAR vision condition, while the ratio approximated to 1 as contrast decreased (0.52 at 95% contrast to 0.77 at 10% contrast) in the CLOUDY vision condition. These results suggested that, whether conscious or unconscious, we tend to prefer smaller print size in the NEGATIVE condition. In addition, it implicated that, for low vision persons with cloudy vision, the tendency was prominent at high contrast levels. [Supported by KAKENHI (#23730851).]

◆ **A reevaluation of area summation of contrast with compensation for retinal inhomogeneity**
 152 A S Baldwin, T S Meese, D H Baker (Aston University, UK; e-mail: baldwias@aston.ac.uk)

Increasing the area of a luminance-modulated sine wave grating decreases its contrast detection threshold. The process by which individual samples from discrete locations in the visual field are combined to achieve this is investigated here by analytic modeling. Several combinations and orders of transduction, template, and summation type were considered. Predictions from these models were compared to spatial summation results measured for two different stimulus types. The first was a set of circular sine-wave gratings (4 c deg^{-1}) of various diameters, including a subset of "Swiss cheese" gratings that were modulated by a raised plaid to halve their total contrast over area (Meese and Summers, 2007 *Proceedings of the Royal Society B* **274** 2891–2900). The second set of stimuli were rectangular grating patches presented both in the fovea and in the periphery replicating Robson and Graham (1981 *Vision Research* **21** 409–18). In other conditions, these stimuli were multiplied by an attenuation surface that compensated for the confounding loss of contrast sensitivity with retinal eccentricity. Our analyses reveal that the full wealth of our results can be described by a single model. This involves spatial filtering, square-law transduction and linear summation of signal and internal noise within a template matched to stimulus extent.

◆ **Spatial integration within and between first- and second-order stimuli**

153 R Summers, D H Baker, T Meese (Aston University, UK; e-mail: r.j.summers@aston.ac.uk)

The detection of first-order (luminance-modulated—LM) and second-order (contrast-modulated—CM) stimuli is believed to involve separate mechanisms that interact weakly or are entirely independent; detection of an LM-only stimulus is barely improved by the addition of CM. However, little is known about the integration of stimuli comprising non-overlapping regions of LM and CM. Spatial summation of LM, CM and LM+CM targets was assessed using (i) full 1.25 c deg^{-1} gratings of different sizes (1–16 cycles), (ii) fixed-diameter targets whose signal area was controlled by modulating a large (8 or 16 cycles) 'full' grating with a raised plaid pattern. The noise carrier (also present for LM stimuli) was bandpass-filtered white noise (8 c deg^{-1} , ± 0.5 octaves). We find that sensitivity improves with target size more rapidly for LM than for CM. When area was constant, comparing full and modulated stimuli yielded summation of $\sim 5\text{dB}$ for both CM and LM. We also investigated cross-order summation, which was weak ($\sim 2\text{dB}$) for full CM+LM (threshold adjusted) stimuli, but stronger ($\sim 3\text{dB}$) when first and second order stimuli were interdigitated over area. This suggests a mechanism capable of integrating textures with attributes that vary over space, perhaps owing to changes in illumination or material properties.

POSTERS: MULTISENSORY PROCESSING

◆ **The effects of size, duration, and luminance of visual line on apparent vertical while the head was tilted**
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A Higashiyama (Ritsumeikan University, Japan; e-mail: achan@lt.ritsume.ac.jp)

We determined orientation of a line that is seen to be vertical (ie, apparent vertical) while the head is tilted with the upright trunk. In this condition, it has been documented that apparent vertical is independent of head tilt (ie, orientation constancy) or is in a direction opposite to the head tilt (ie, the Müller effect). The most of previous studies regarding apparent vertical, however, have focused on the effect of head tilt but have been less attended to the parameters of the visual line by which apparent vertical is judged. In this study, we manipulated size (5.5 and 22 deg arc in visual angle), duration (0.1 s, 3 s, and no time limit), and luminance (0.026, 0.003, and 0.001 cd m^{-2} against total darkness) of the line with the head being tilted within 30 deg arc. The main findings were: (1) the line of shorter duration or of lower luminance facilitated the Müller effect and (2) apparent vertical for the line of small size leaned toward the left

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of that for the line of large size. These results are not explained by the theory of taking head tilt into account but are explained by modifying the sensory-tonic field theory.

◆ **Auditory stimuli modulates visual time dilation illusion**

155 T Kayahara (Dept of design and information systems, Miyagi University, Japan;
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Previous studies reported an illusion in which motion information of visual stimuli can lengthen the perceived duration of those (Brown, 1995 *Perception and Psychophysics* **57** 105–116), and suggested that the illusion is based not on retinotopic- but on spatiotopic-level visual processing. (Au et al, 2012 *Frontiers in Psychology* **3**(58) 1–7) Meanwhile, other multimodal studies reported the dominance of auditory information in the time-domain perception. (eg Shams et al, 2000 *Nature* **408**788) Thus, in this study, the author examined whether the accompaniment of auditory stimuli with the time dilation illusion can modulate lengthened duration of visual stimuli in the illusion, mainly with the condition of the auditory motion. (auditory motion either by inter-aural time difference (corresponds to retinal motion) or by real speaker array (corresponds to spatial motion), or static sound (without any motion)). The relation between across-modal object representation and the time perception will be discussed with obtained auditory modulation on the visual time dilation illusion. [Supported by JSPS (No.23500261).]

◆ **Similar systematic biases in visual and vestibular heading perception**

156 L Cuturi, P MacNeilage (Vertigo research center (IFB) University Hospital Großhadern-LMU, Germany; e-mail: luigi.cuturi@gmail.com)

Visual and vestibular sensory information is processed by the brain in order to perceive direction of linear self-motion (ie heading). Visually, translation in space results in a characteristic retinal flow pattern: its focus of expansion provides information about heading direction. In the vestibular system, otoliths signal changes in linear acceleration allowing the brain to identify heading direction. Here we investigate accuracy of visual-only or vestibular-only heading judgments. Optic flow stimuli presented in stereo are used to investigate visual heading perception, whereas linear self-motion translation on the earth-horizontal plane is delivered to elicit a vestibular response. Subjects are asked to indicate the heading angle of the experienced motion (visual or vestibular) by adjusting the angle of a visually presented arrow. Accuracy of both visual and vestibular judgments depends significantly on heading angle. Heading directions close to the obliques (ie 45° and 135°) are the most biased, showing significant overestimation for forward directions and significant underestimation for backward directions. Visual and vestibular biases are significantly positively correlated and do not significantly differ for forward movement directions. Similarity between visual and vestibular heading biases suggests a common spatial representation influences heading judgments regardless of the sensory modalities involved.

◆ **The central tendency of judgment: a consequence of Bayesian estimation?**

157 N Roach¹, J Heron², P McGraw³, D Whitaker² (¹The University of Nottingham, UK; ²University of Bradford, UK; ³The University of Nottingham, UK;
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A common finding in reproduction and estimation experiments is that judgments are compressed around a central value—the magnitude of stimuli falling below the mean of the range is typically overestimated, whereas the magnitude of stimuli above the mean is underestimated. This pervasive bias was first noted in studies of temporal interval perception by Vierordt (1868, *Der Zitsinn nach Veruchen*, Tübingen, Laupp), but has since been documented across a range of different sensory judgments. Recently formulated Bayesian observer models suggest this bias arises from the optimal fusion of noisy stimulus measurements with acquired knowledge of the set of stimuli from which it is drawn. However, in a series of duration reproduction experiments, we demonstrate that interleaving stimuli sampled from distinct, non-overlapping ‘short’ and ‘long’ distributions produces compression of estimates around a single duration value, even if the distributions are widely separated and clearly demarcated by way of spatial location, sensory modality or temporal sequence. These results are at odds with the simulated biases of a Bayesian observer model with prior expectations matching either one of the stimulus distributions or their combination.

◆ **Audio-visual synchrony detection under scotopic conditions**

158 J Cass¹, K Churrua¹, E Van der Burg², D Alais² (¹University of Western Sydney, Australia; ²University of Sydney, Australia; e-mail: davida@usyd.edu.au)

In cluttered visual displays, abrupt, uniquely synchronised audio-visual events capture attention. This study compares the temporal determinants of this 'pip and pop' phenomenon under photopic and scotopic conditions. In conjunction with prolonged dark adaptation, scotopic conditions were achieved using goggle-mounted neutral density filters. The primary task involved identifying the orientation of a target singleton, horizontally or vertically presented among 5, 9 or 13 distractor lines tilted ($\pm 4^\circ$: photopic; $\pm 10^\circ$: scotopic) from horizontal and vertical. Target and distractor elements were each surrounded by a luminance-defined annulus modulating at 0.78 Hz, each with a unique temporal phase. On half of the trials an amplitude-modulating 500Hz tone was synchronised with the modulation of the target annulus and was absent on the remaining trials. The modulation profile of luminance and tone was sinusoidal or square. For sinusoidally modulating trials, the presence of the tone had no effect, with highly serial search performance under both illumination conditions. For square-wave trials the presence of the tone dramatically improved search efficiency only under photopic conditions, with no tone-related improvement observed scotopically. This result persisted after advancing the tone in time to account for luminance-related lags in neural latency. Contrary to predictions based on the scotopic temporal channels literature, the effects of illumination on AV synchrony-driven visual search appear to result from a profound low-pass temporal filtering within the scotopic system.

POSTERS: MULTISTABILITY

◆ **The association between dopamine-related gene polymorphisms and perceptual stability**

159 M Sekutowicz¹, K Schmack¹, H Rössler¹, E J Brandl², D J Müller¹, P Sterzer¹
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Key features of bistable perception are high intra-individual stability and high inter-individual variability in perceptual switch rates. There is some evidence for a contribution of genetic factors to switch rate as an individual trait. Slow perceptual switching has been reported in bipolar disorder (BD), a highly heritable condition. Given previous findings from pharmacological studies and the association of BD with dopaminergic dysfunction, we hypothesized that dopamine-related candidate genes for BD may modulate switch rates in bistable perception. We tested the association of two VNTRs within DRD4 and DAT1, both candidate genes for BD known to alter dopaminergic neurotransmission, with bistable perception in 112 healthy human subjects. The occurrence of the 2 repeat allele (2R) in the DRD4 VNTR was significantly associated with slow perceptual switching ($p = 0.009$), but no effect was found with DAT1 VNTR polymorphism. Both, the increased frequency of 2R in BD and our result are consistent with the previous association of BD with slow perceptual switching. Altered dopamine levels associated with an intermediate cAMP inhibition potency mediated by 2R may thus reduce perceptual switching, suggesting that differences in dopaminergic neurotransmission may indeed account for inter-individual variability in perceptual switch rates.

◆ **Memory effects in bi-stable depth-order perception: Adaptation and beyond**

160 N Kogo, D Stuer, E Acke, R van Ee, J Wagemans (University of Leuven [K U Leuven], Belgium; e-mail: johan.wagemans@psy.kuleuven.be)

The context sensitivity of figure-ground organization (or depth-order perception in general) must be reflected in the locally assigned signals of neurons in the lower level visual cortex, who are sensitive to the border-ownership (BOWN). This suggests a feedback system in which the BOWN computation is influenced by the depth order, while the depth order is constructed from BOWN signals. We recently developed a neuro-computational model (Kogo et al, 2011 *Vision Research* **51**(18), 2085–2098), which implemented this idea. By adding noise and adaptation, it can reproduce bi-stable depth-order perception. The model predicts that an intermittent presentation of the image will cause a prolongation of the alternation, as in other classes of bi-stable perception (Leopold et al, 2002 *Nature Neuroscience* **5**(6), 605–609). In this study, we investigated this prolongation effect in Kanizsa's anomalous transparency figure (KAT), the face-or-vase figure (FV), and in the Necker cube (NC). The prolongation effect was observed in KAT and NC but not in FV. In addition, we will report results from subjects seeing the figures intermittently by opening and closing their eyes. If the prolongation is further enhanced, it may suggest that the higher level expectation biases our perception.

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◆ **Individual differences in matching and labelling facial expressions: is there an association with the ability to recognise vocal expressions or facial identity?**

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R Palermo¹, K B O' Connor², J M Davis², E McKone², J Irons² (¹University of Western Australia, Australia; ²Australian National University, Australia; e-mail: romina.palermo@uwa.edu.au)

Facial expressions are an important cue for everyday social interactions. We developed tests to reliably assess the ability of individuals to match (select which one of three faces displayed a different expression) and label (select one of six verbal labels) facial expressions and examined three theoretical questions: (i) the extent to which the ability to match facial expression is associated with the ability to label facial expression, (ii) the relationship between the ability to judge expressions from faces and voices, and (iii) the relationship between the ability to judge expression and identity from faces. There was a moderate correlation between the ability to match and label facial expressions. The ability to label vocal expressions was not correlated with the ability to match facial expressions, but there was a small relationship with the ability to label facial expressions. This suggests that labelling tasks may tap into a multi-modal system for emotion processing (ie, recognition of emotion from faces or voices) whereas the matching task taps perceptual processes involving faces. We also found that the ability to recognise facial expressions was moderately correlated with the ability to recognise facial identity from faces, consistent with claims for common early processing.

POSTERS: SPATIAL VISION

◆ **Genome-wide association methods reveal genetic contributions to visual detection of orientation**

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P T Goodbourn, G Bargary, J M Bosten, R E Hogg, A J Lawrance-Owen, J D Mollon (University of Cambridge, UK; e-mail: p.goodbourn@psychol.cam.ac.uk)

The human visual system can use cross-correlation or auto-correlation to compute the orientation of a texture (Barlow and Berry, 2011 *Proceedings of the Royal Society B* **278**2069–75). Both processes are probably mediated by V1 neurons. Here, we offer a first insight into the genetic basis of individual differences in orientation discrimination by cross- and auto-correlation. As part of the PERGENIC project, 1060 participants reported the orientation of streaks in random dot gratings, which were generated by two methods: either by sinusoidal modulation of dot density across space (best detected by cross-correlation), or by the introduction of coherently oriented dot pairs to create Glass patterns (best detected by auto-correlation). We then performed a genome-wide association study (GWAS) to search for associations between psychophysical performance and single nucleotide polymorphism (SNP) markers distributed throughout the genome. Across the two classes of stimuli, we found significant associations ($p < 0.0000005$) for 13 SNPs, and suggestive associations ($p < 0.00001$) for a further 149 SNPs. These SNPs constitute 14 independent association regions across nine chromosomes. Our results highlight the considerable potential of GWAS to advance the understanding of fundamental processes in visual perception.

◆ **Feature integration in visual shape detection and discrimination**

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Empirical evidence suggests that the visual system efficiently combines information from different feature cues to establish a stable perception of shape. The locations and procedures of mechanisms in the visual cortex responsible for feature integration are yet to be determined. We report results from two experiments employing a dichoptic presentation paradigm to show a) different shape defining parts or b) different shape defining features to each eye. Shapes consist of Gabor or line elements, having feature contrast against the background in orientation, spatial frequency, color, or pairwise combinations of these. Shape detectability and discriminability from the single-cue conditions and double-cue conditions are measured in a 2AFC task. Performance in the double cue-conditions is then compared against various benchmarks derived from the single-cue conditions, such as probability summation and linear integration. Performance in the double-cue conditions from both experiments consistently exceeds the predictions based on the assumption of independent feature processing. Our results suggest that feature integration precedes shape detection and is implemented early in the visual pathway. However, we find clear evidence that the integration of basic features like orientation and spatial frequency must occur in areas of the visual pathway where information from both eyes is already fused, thus rendering V1 an unlikely candidate for the site of joint feature processing.

◆ **Temporal dynamics of relative spatial frequency tuning of human perception**

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In the present study, we investigated stimulus size dependency of spatial frequency tuning of human perception using psychophysical reverse-correlation method. All participants exhibited significantly stimulus-size-dependent absolute spatial frequency tunings (cycles/deg) such as increasing stimulus size decreased the peak spatial frequency. Then we calculated relative spatial frequency tuning (cycles) by multiplying absolute spatial frequency (cycles/degree) with stimulus diameter (degrees). We found that all participants exhibited almost perfect image-based spatial frequency tuning from response onset to response offset with fixed peak. Observed relative spatial frequency tuning was contrast invariant, although at low contrast (1%), optimal stimulus size was relatively larger than that at high contrast (90%), suggesting the most visible relative spatial frequency was contrast dependent. These results suggest that the relative spatial frequency tuning is a fundamental property of human perception.

◆ **Depth of field and visual discomfort**

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Cue conflict between depths specified by accommodation and vergence, which may arise under stereoscopic viewing, has been reported to cause discomfort (Shibata et al, 2011 *Journal of Vision* **11**(8), 1–29). Depth-of-Focus (DOF) is a related depth cue (Vishwanath and Blaser *Journal of Vision* **10**(10) 1–16) that occurs as a result of aperture (pupil) size and object distance to focal plane. Appropriate DOF increases performance on stereoscopically presented visual tasks (Hoffman and Banks *Journal of Vision* **10**(5), 1–17). In this experiment, we investigated whether incorrect DOF, as calculated based on the optics of the eye, causes discomfort. Stereoscopic photographs of objects with varying levels of DOF, too large, too shallow, or appropriate, were viewed whilst doing a visual dot counting task. Whereas increasing DOF blur increased headache and distortion ratings, surprisingly, more discomfort and eyestrain were reported with appropriate DOF than with inappropriate DOF. Reports of dry eyes were only affected by DOF in the presence of a simultaneous accommodation-vergence conflict. There was a peak in accuracy in a dot-counting task with appropriate DOF, in the absence of accommodation-vergence conflict. These results suggest that DOF is not useful alone in minimising discomfort, but can mediate effects of pre-existing cue-conflict.

◆ **Cityscape impressions from Harbin historical postcards**

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We examined the cityscape impressions from historical postcards in terms of the semantic differential techniques. We used 695 Harbin postcards, which depicted three areas (Fujiadian, Pristan District, and Novi Gorod Street) of Harbin, China in the three different periods (before the Bolshevik revolution, before the Manchurian Incident, and the period of Manchukuo) from the Digital Archives of Asian Historical Material of Nihon University in Japan. The experiment was blocked by area and period of them. Each block showed ten cards which were randomly selected from the appropriate group of the cards by participant in random order. After observing them, each participant rated their impressions of the cityscape on each 5-point scale of thirty adjective pairs. A factor analysis of the ratings revealed five factors which were interpreted as activity, urbanity, solemnity, evaluation, and familiarity. We also conducted two factorial (three periods × three areas) MANOVA for five factor scores and subsequent tests. The results seem to correspond to some historical interpretations for three different periods of the three areas. We will discuss the possibility of psychological approach to some historiographical study based on these results.

◆ **Influences of temporally preceding contexts on boundary extension**

167 A Egawa¹, E Kimura² (¹Graduate School of Humanities and Social Sciences, Chiba University, Japan; ²Dept of Psychology, Faculty of Letters Chiba University, Japan; e-mail: kimura@L.chiba-u.ac.jp)

Boundary extension (BE) refers to a phenomenon in which a close-up photograph of a scene is remembered as containing surroundings that may have been present beyond the boundaries of the photograph. BE has been assumed to reflect an anticipatory processing; a limited view of a scene provided by a photograph is recognized within a likely spatial layout of the scene and the expected space

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is remembered as having seen. We reasoned that the anticipatory processing would be largely affected by preceding contexts, and tested this prediction. The stimulus composed of a successive sequence of three photographs zooming in or out on a scene and the last one was always a medium-angle photograph. BE was measured with a boundary adjustment task. The results showed that BE was much larger in the zooming-out condition, where successively appearing surroundings would have enhanced the expectation of the space beyond the boundaries and facilitated the anticipatory processing. Moreover, a smaller but significant BE was also found in the zooming-in condition, where the space beyond the boundaries was presented beforehand and thus the anticipatory processing would not have been activated. These findings suggest that the integration of successive views of a scene also contributes to BE.

◆ **Scene categorization at large visual eccentricities**

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Studies on scenes perception have shown that the visual system is particularly sensitive to the global properties, or overall layout of a scene. Such global properties cannot be computed locally, but rather require relational analysis over multiple regions. To what extent does observers' perception of these global properties suffer in the far periphery? We examined how some global scene properties resist the decrease in spatial resolution as eccentricity increases from 10 to 70°. Pairs of photographs of scenes were simultaneously presented left and right of fixation for 80 ms on a panoramic screen (5 m diameter) covering the whole visual field. Central fixation was controlled. Observers were instructed to press the key corresponding to the spatial location left/right of a pre-defined target. We found that classification of global scene properties was accomplished with a performance highly above chance (around 70% correct) in the far periphery at 70° eccentricity. The perception of some global properties (eg, naturalness) was more robust to the low resolution of peripheral vision than others (eg, indoor/outdoor) that required a more local analysis. These results are consistent with the hypothesis that coarse features may capture the diagnostic image information needed for scene categorization.

◆ **Psychophysical point: a disc becomes a point when Weber's law fails**

169 H Ono¹, E González², L Lillakas¹ (¹CVR, York University, Canada; ²Vision Science Research Program, Toronto Western Hospital, Canada; e-mail: hono@yorku.ca)

In geometry, a point has a location but no area. It is an abstract concept and does not exist in the physical world. At ECVF (2008) we reported a series of experiments showing that the visual system treats a small disc (ie, a dot) as a point. Here, we report the results of another experiment that shows the same. We placed the relative retinal image size cue for depth for dots and discs in conflict with the motion parallax cue to compare their accuracies with their jnd values. Pairs of dots and discs were presented on a computer screen; their movements were yoked to the observers' head movement (equivalent disparity of 0.08°). There was a 12% difference (above the jnd value for the dots) in the size of the dots (discs): 0.08° and 0.07° (1.5° and 1.32°). The results showed that the accuracy was higher for the dots (ie, motion parallax was a more effective cue for the dots). We further confirmed the hypothesis that a dot provides information about its location but not about its area, because the discriminability of a dot as indicated by its Weber's fraction is low in comparison to that of a disc.

◆ **Sensitivity to numerosity is not a unique visual psychophysical predictor of mathematical ability**

170 M S Tibber¹, G S Manasseh¹, R C Clarke¹, G Gagin², S N Swanbeck³, B Butterworth³, R B Lotto¹, S C Dakin¹ (¹Institute of Ophthalmology, UK; ²Wellesley College, USA; ³Institute of Cognitive Neuroscience, UK; e-mail: mtibber@yahoo.com)

Individual differences in children's sensitivity to visual number (the ability to discriminate the numerosity of dot arrays) significantly predict mathematical performance. We examined the specificity of these findings in a broader population that included adults and asked whether other forms of visuospatial sensitivity similarly predict mathematical performance. Over 300 observers (6–73 years of age) performed a timed computer-based mathematics test followed by a batch of visual matching tasks, in which observers had to match two clusters of Gabor blobs with respect to their numerosity, density, size or orientation. Performance on all tasks undertaken (mathematical and visuospatial) improved with age, and there was a significant trend for better performance amongst male participants. When all visual thresholds, mathematics scores and self-reported education levels were subjected to a principal components analysis two significant factors emerged; one of these linked mathematics scores to

general visuospatial sensitivity as measured by performance on all visual tasks tested. Further, although sensitivity to visual numerosity emerged as a significant predictor of mathematics scores once other parameters were controlled for, so did size and orientation acuity. These findings are consistent with visual numerosity tasks sharing resources with symbolic mathematics, but suggest that the critical factor is not numerosity itself.

◆ **Backward masking reveals different visual processing of schizophrenic and depressive patients**

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Visual backward masking is a very sensitive tool for studying early visual processing deficits and a reliable endophenotype of schizophrenia. Mental diseases strongly overlap in many aspects, for example, in psychopathology, cognition, and genetics. Here, we show that strong masking deficits are found in patients with functional psychoses but not in non-psychotic patients, namely, depressive patients and abstinent alcoholics. We tested 28 schizophrenic, 22 schizoaffective, 20 bipolar patients, 26 major depressive patients, 23 abstinent alcoholics, and 24 healthy control subjects with various variants of the shine-through masking paradigm. Patients with schizophrenia, schizoaffective disorder, and bipolar disorder, show strongly prolonged SOAs compared to controls. Patients with unipolar major depression and abstinent alcoholics, however, perform like healthy controls. We suggest that patients with functional psychoses suffer from similar visual dysfunctions whereas visual processing of depressive patients seems to differ. [The work was supported by the Volkswagen Foundation.]

◆ **Is texture segregation strictly feedforward?**

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Segregation of visual texture is a process driven by differences in the local spatial relations among elements similar in appearance. This process facilitates detection of region boundaries and is a key step leading to distinction of a figure from its background. It remains unclear whether this process can be solely ascribed to a feedforward processing stream or if recurrent or feedback information is needed. Using textures composed of random line arrays, and generated randomly for each trial, we employed a response priming paradigm to examine participants' ability to process textures within early vision. As predicted, local visual prime signals served to enhance/hinder visuomotor responses. In the absence of a local-defined prime the global features continued to influence speeded motor responses. Interestingly, a negative priming effect was observed in the control condition. In this case, the role of attention (task set) and perceptual learning is explored. Altogether these results reveal early processing of visual textures. By analyzing the time-course of in-vivo primed motor responses we make the case for a strictly feedforward account of texture segregation.

◆ **Investigation of the inattentive blindness for dynamic events as a result of saccadic suppression**

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The aim of our work—the investigation of the well-known Inattentive Blindness (IB) effect (Neisser, and Becklen, 1975 *Cognitive Psychology* 7 480–494; Simons and Chabris, 1999 *Perception* 28 1059–1074). Most demonstrations of the IB effect comprise the instruction to follow the target by the saccadic eye movements. This implies that IB can arise due to the saccadic suppression taking place in this task. In psychophysical experiments we analyzed eye movements during watching the classic and modified paradigm of dynamic IB tasks with different instructions. Instructions were supposed to evoke saccadic eye-movements with different parameters. We also varied the angular size of the testing images to analyze the importance of the perceptual area during eye fixations. The area of inattention depended on the instruction and the angular size of the test images. Obtained results are discussed in terms of different activity of Magno- and Parvo- system during saccades and fixations. We conclude that the IB effect in the classic dynamic IB paradigm could be explained not only by the mechanisms of attention

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but also by the well known effect named “Saccadic Suppression” (Burr, Ross, Binda, and Morrone, 2010 *Cell* **12**(14), 528–533).

THURSDAY

POSTERS: ART AND VISION

◆ **Drawing expertise predicts not just quality but also accuracy**

¹ L Carson¹, M Millard², N Quehl¹, J Danckert¹ (¹University of Waterloo, Canada; ²Stanford University, USA; e-mail: lccarson@uwaterloo.ca)

Drawing is complex. When people draw representationally from close observation of a subject, the completed drawing is a product of many factors: their visual perception, analysis and knowledge of the subject; their ability to translate that information to the page; their judgment of which properties of the subject and of the drawing are most important to success; and, their ability to detect and correct errors in the drawing as they go. In order to tease apart the successes and failures of these contributing factors, we developed and validated objective measures of local and global drawing accuracy. We analyzed shapes in the image as polygons with vertices at unambiguous landmarks and measured four independent dimensions of drawing error of those polygons: orientation, position, scaling and proportionality. We collected 34 drawings of a complex still life and over 100 qualitative ratings of those drawings. The ratings and overall polygon accuracy were consistent with the drawing expertise of participants, and experts were more accurate than novices on every dimension of polygon error. We discuss prospects for the validation and improvement of drawing training, and how these measures can contribute to the study of visual perception.

◆ **The specificity of art revealed by an empirical study on multi-cultural aesthetic material**

² J Boehringer, C C Carbon, S J Faerber (Dept of General Psychology and Methodology, University of Bamberg, Germany; e-mail: janaboehringer@gmx.de)

Research in the field of empirical aesthetics often uses definitions, theories and experimental paradigms for aesthetics quite arbitrarily, especially by using artworks as just one typical class of aesthetically relevant material among other comparable domains. We demonstrate the exclusiveness of visual art by analyzing the specific relationships between key variables of aesthetics in different domains. Participants evaluated material from five visual categories (artworks, costumes, faces, houses, landscapes) originated from four different countries (Austria, Germany, Japan, Tanzania) on two main variables associated with aesthetic appreciation—familiarity and liking—and classified the material's country of origin. Familiarity and liking were only related for artworks ($R > 0.85$) demonstrating a general preference for art being familiar, an empirical pattern not observable for the other classes of material. This indicates that preferred artworks should not be accompanied with too much uncertainty and arousal. Even more interesting, when analyzing the data on a stimulus level, specific artworks did not benefit when being evaluated as familiar vs unfamiliar, but strongly gained liking when the material was correctly classified. This specific pattern was observed for artworks but not for any other class of material, underlining the importance of successful classification, for the appreciation of the arts.

◆ **What is the main ingredient for transforming an ordinary object to a piece of art?**³ **Aesthetic evaluations on objects of judgments ambiguous art quality**

M Härtel, C C Carbon (University of Bamberg, Dept of General Psychology and Methodology, Germany; e-mail: claus-christian.carbon@uni-bamberg.de)

There is a fast growing body of empirical studies on aesthetic appreciation and aesthetic judgment, particularly on visual art. It is, however, still under debate what main ingredient is needed to identify an object as a piece of (modern) art. We know from recent questionnaires studies on aesthetic judgments that visual art is tightly linked with variables such as stimulus-symmetry, complexity, familiarity, artistic style, appeal to social status, and personal preferences (eg, Augustin et al, 2012 *Acta Psychologica* **139**(1), 187–201). We specifically aimed to find out which variables are mainly accountable for creating artistic quality of objects of ambiguous aesthetic quality. To cover a wide spectrum as possible, we utilized 213 objects in total and asked persons who were untrained in art perception to assess the objects variables commonly summed to be linked with artistic quality. Out of the used variables (preference for the objects, originality, ambiguity, understanding of the objects), the variable originality served as the best predictor for artistic quality, whereas preference was found only of minor importance. Additionally, high artistic quality was often related to higher degrees of ambiguity and lower degrees of understanding.

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◆ **How should I place two rectangles so they look best?**

4 F Samuel, D Kerzel (Université de Genève, Switzerland; e-mail: Francoise.Samuel@unige.ch)

We observed that in the absence of symmetry, equilibrium does not explain, or only to a small degree, whether a composition is considered aesthetically pleasing. We define equilibrium in visual compositions in an analogous way as in physics: dark areas represent weights and a composition is equilibrated when the center of mass of the dark areas is in its center. Although the position of the center of mass of the composition has nearly no impact on the ratings, does it interact with other properties of the composition in order to influence the aesthetics ratings? We varied the shapes and the area ratios of the two rectangles making up the compositions, and also the position of the center of mass of the compositions. Our results show an interaction between the position of the larger rectangle and the position of the center of mass. That is, for a given position of the center of mass either on the left or on the right, compositions in which the larger rectangle is on the side of the center of mass are preferred over compositions in which the smaller rectangle is on the side of the center of mass.

◆ **Perspective errors masked by architectures in paintings**

5 I Chen, C Lin (Institute of Applied Art, Chiao-Tung University, Taiwan, Taiwan; e-mail: iping@cc.nctu.edu.tw)

Ever since the discovery of the principles of linear perspective, Renaissance masters and their numerous followers in the Western tradition seemed to acquire a peculiar obsession with depicting architectural elements in their paintings. In this study we proposed and tested the hypothesis that architectural settings might have helped to cover up minute perspective errors or inconsistencies on the figural part of the painting. A total of nine paintings, mostly from Renaissance era, were used as stimuli of this study. The figural theme on the foreground of each painting was cut out from the original image. The remaining blank area was carefully filled in by interpolating the background details. Thus two separated pictures, one with the figure only, another with the background and devoid of the figure, were obtained. A method of limit procedure was used to measure the viewer's sensitivity to detecting perspective errors. The figural theme were either presented on a blank or on the original background. We found that the tolerance for errors was lower in the blank background condition. Our results indicate that imposing architectures might evoke a dominant impression of perspective-correctness, which effectively masks the detection of perspective errors on other parts of the painting.

◆ **What 80 Lisas can reveal about Leonardo's Mona Lisa: One step further in demystifying**

6 **La Gioconda's absorbing smile**

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From an art historian perspective, Gombrich has already unraveled the main characteristic of Mona Lisa's smile: Ingeniously using local sfumato technique, that is creating primarily low spatial frequencies around the corners of the mouth, Leonardo da Vinci created the impression of a smile emerging only when the mouth is perceived peripherally. Until now, only an eyetracking experiment tested Gombrich's hypothesis by applying eye-contingent display changes to simulate the dissociate perception of the expression of the mouth when perceived peripherally (smile) versus centrally (neutral) (Bohrn et al, 2010 *Psychological Science* 21378–380). The present study follows a more direct approach by generating out of a sample of 20 female faces 2 (NeutralMouth vs SmilingMouth) x 2 (NeutralSfumato vs SmilingSfumato) = 80 versions, with the NeutralMouth-SmilingSfumato-version ("MonaLisa-version") as an analogue to the specific application of sfumato in Leonardo's masterpiece. Participants rated the MonaLisa-version as being the most mysterious of all versions, and as being significantly more smiling and beautiful than the respective NeutralSfumato-version. The specific combination of the perception of intensified smile and beauty together with a strong feeling of mysteriousness induces strong dynamics in the perceptual system, which seems to be the reason for generating the ongoing fascination for La Gioconda.

◆ **Simple and constructive visual mental imagery are behaviorally and neurally separable**

7 A Schlegel, P Kohler, S Fogelson, P Tse (Dartmouth College, USA; e-mail: peter.j.kohler@dartmouth.edu)

If you ask a bonobo what you get when you cross an elephant with a rhino, he likely won't have the slightest clue. If you ask me, however, I can vividly imagine an elephino with two tusks and two horns, charging through the savanna. Human creative activities such as language, art, and science indicate that we have evolved robust machinery for synthesizing new concepts. But we know little about the

neural basis of this machinery. Here we use fMRI and DTI to investigate a specific example of human creativity we call constructive imagery: the synthesis of novel mental visual images given only their component parts. We developed a set of segment stimuli that could be assembled in 2x2 arrays to generate complete figures ranging from simple to complex. Subjects performed two tasks with these stimuli: they either viewed sequentially-presented complete figures and held them in working memory, or mentally constructed a figure during sequential viewing of its four segments. Subjects were required to choose the previously seen or constructed figure from among distractors after a delay. Performance in the two tasks was not significantly correlated, and we identified several brain regions that were selectively recruited during constructive imagery.

◆ **There's more than one way to irritation! An attempt to categorize ambiguity in art**

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Irritation is not definable by outside-characteristics but is elicited by inconsistencies between internal states (Zschocke, 2006, Munich, Fink). The principle of exclusivity calls for only one clear interpretation at a time thus explaining why we perceive a sudden switch between interpretations when bi-stable pictures are perceived. Zeki (2004, *Consciousness and Cognition*, **13**(1), 173–196) defines ambiguity accordingly as the existence of multiple possibilities or schemata in contrast to uncertainty. We extracted several categories of ambiguity out of multi-dimensional semantic scales gathered for the perception of modern art that go beyond ambiguity as a simple “switch” of interpretations. Examples out of experiential reports further indicate that contradictory elements can be found on several levels of processing including imagination, association and simulation processes. We propose that modern art is capable of fusing unsolvable contradictions in various ways. Several theories suggest that elaboration of these ambiguities (Ramachandran and Hirstein, 1999 *Journal of Consciousness Studies* **6**(6–7), 15–51) and specifically the reduction of prediction-errors (Van de Cruys and Wagemans, 2011 *i-Perception* **2**(9), 1035–1062) are linked to aesthetic appreciation which underlines the relevance of looking closer at the several ways of irritation in art.

◆ **How heavy is red? Towards a psychophysical framework of color weights**

⁹ M K Groh, C C Carbon (Dept of General Psychology and Methodology, University of Bamberg, Germany; e-mail: ccc@uni-bamberg.de)

From a physical point of view, colors derive from the spectrum of light and are by definition zero-g. As vision scientists are quite uninterested in definitions of mere physical properties but try to understand and analyze the empirical world caused and framed by the cogni-perceptual apparatus, we aimed to measure the weight of certain colors. To enable detecting even subtle differences between “psychological weights” of colors we decided to use relative weight judgments of two identical spheroids per trial. Physical weight was re-measured after each experimental session with a precision of <0.1 g for targets of 70 g. Furthermore, participants were checked for personality traits and their affective state before and after the testing. Participants showed highly consistent relative weight estimations, but only if they had low scores on the neuroticism scale: then they estimated violet and black as heaviest, followed by blue, white, green and orange with the lightest colors being red and yellow. This data pattern is quite remarkable as weight estimation was not directly related to important visual color aspects saturation or lightness, but strongly related to energy of light measured in electronvolt (eV) opening up the possibility for establishing a psychophysics of color weights.

◆ **Naive observers' perception of beauty, glossiness and inference color of pearls:**

¹⁰ **Comparison with expert appraiser**

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Aesthetic perception is influenced by processing fluency (Reber et al, 2004 *Personality and Social Psychology Review* **8**(4) 364–382). For instance, symmetric figures are preferred and judged beautiful. We focused on aesthetics perception of real objects such as pearls. Experts appraise pearls' beauty. However, it has not been investigated whether the appraisal reflects naive observers' aesthetic perception. We aimed to investigate how naive observers judge beauty of pearls in relation to perception of glossiness and inference color, and whether it correlates with expert's appraisal. Twenty-three

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naive participants ranked nine pearls based on beauty, then ranked them based on perceived glossiness and inference color. They were unaware of glossiness and color judgments until completing the beauty judgment. Judged beauty correlated with image skewness (glossiness index) and inference-color index (partial correlation, skewness: $r = 0.36$, inference color: $r = 0.25$), but it was weaker than expert's ranked beauty (skewness: $r = 0.78$, inference color: $r = 0.90$). Perceived glossiness well correlated with both skewness ($r = 0.62$) and inference color ($r = 0.65$). Thus, expert's appraisement more correlated with perceived glossiness ($r = 0.77$) than judged beauty ($r = 0.13$) and perceived inference color ($r = -0.17$). These results suggest that our naive perception of glossiness would be a source of experts' appraisement since glossy objects are salient and processed fluently.

◆ **Effects of mere exposure and abstractness on aesthetic preference of visual stimuli in children**

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D Jankovic (Laboratory for Experimental Psychology, Dept of Psychology, University of Belgrade, Serbia; e-mail: djankovi@f.bg.ac.rs)

According to the two-step theory of the mere exposure effect, repeated exposure to a stimulus enhances subjective feeling of perceptual fluency, which in turn influences preference for old over new stimuli. However, the findings obtained in children are not so ubiquitous. The present study was aimed at examining relations between two different perceptual fluency measures and aesthetic preference of visual stimuli in 9 year old children. Perceptual fluency was manipulated in two ways, by abstractness (visual stimuli with high and low content accessibility) and frequency of exposure (0, 2 and 5 exposures) in within-subjects design. Following the exposure phase, participants judged presented stimuli on the seven-step bipolar beautiful-ugly scale. The results showed that effects of mere exposure were opposite for stimuli with high and low content accessibility. Repeated exposure to a stimulus with high content accessibility increases the liking, while repeated exposure to a stimulus with low content accessibility decreases the liking.

◆ **Perceptual fluency does not necessarily increase aesthetic appreciation: Evidence against the Hedonic Fluency Model**

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Aesthetic pleasure is a function of the perceiver's processing dynamics. According to the Hedonic Fluency Model (Winkielman et al, 2003, in *The Psychology of Evaluation: Affective processes in cognition and emotion* J Musch and K C Klauer, Mahwah, Erlbaum), the perceptual fluency of a stimulus has an influence on affective judgments about this stimulus. This so-called Fluency Affect Link predicts higher positive judgments with increasing perceptual fluency. In the present experiment, stimuli of different levels of complexity and of positive as well as negative valence from the IAPS database were tested for their aesthetic appreciation. Perceptual fluency was manipulated through perceptual priming. Contrary to the predictions of the Hedonic Fluency Model, participants' ($n = 20$) aesthetic appreciation only benefited from fluency of stimuli with positive, but not with negative valence. Actually, stimuli with negative valence were judged more negative in the highly fluent than in the low fluent condition. These findings are compatible with the Fluency Attribution Hypothesis (Jacoby et al, 1989, in *Varieties of memory and consciousness: Essays in honour of Endel Tulving*, H L Roediger and F I M Craik, Hillsdale, Erlbaum), asking for an adaptation of current research hypotheses often derived from the Hedonic Fluency Model.

◆ **Systematic assessment of emotional expression using facial animation techniques**

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K C Scott-Brown, B Robinson, M Fhionna, M Cook, S Martinez, R J S Sloan (University of Abertay Dundee, UK; e-mail: r.sloan@abertay.ac.uk)

Research on emotional expression tends to use static faces and classic emotions. We report a series of experiments using digital animation techniques to assess the extent of emotional expression recognition for a range of artistically defined emotional expression choreographies varying the sequence of animation from the eyes and the mouth. Artistic theory prediction suggests that authentic emotional expression should be led by the upper half of the face. We constructed dynamic emotional expressions with 5 facial animation sequences, eyes then mouth, eyes and mouth overlapping in time, simultaneous mouth and eye animation, overlapping mouth and eyes or separate mouth and eyes. The six emotional expressions were presented in a random sequence to 30 observers. Emotional expressions were recognised above chance, and authenticity judgments favoured upper face leading animations. Given a secondary emotion label opportunity, disgust and fear were included in each-others descriptions, consistent with artistic

prediction. The results show how a systematic approach to facial animation can test predictions from the artistic method. In addition, the use of computer-generated faces can be used to create emotional test stimuli that are able to test the extent of emotional expression recognition in a systematic manner not possible with human actors.

◆ **The influence of a product's perceived social function on aesthetic pleasure for visual product designs**

14 J Blijlevens, P P Hekkert (Delft University of Technology, Netherlands;
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Aesthetic pleasure for product designs is often researched through manipulating visual properties of design (eg, symmetry and complexity). We contribute by researching how perception of a product design's social function influences aesthetic pleasure. People have the inherent social needs to feel autonomous and to feel connected to others (Brewer, 1991 *Personality and Social Psychology Bulletin* 17475–482) and use product designs to express their autonomy or to whom they are connected (Belk, 1988 *Journal of Consumer Research* 15139–168). From an evolutionary perspective, product designs provide aesthetic pleasure, because it helps direct beneficial behavior for people's survival (Tooby and Cosmides, 2001 *Substance* 94/95 6–27). Consequently, we argue and investigate that product designs that help fulfill people's social needs are aesthetically pleasurable. Respondents rated visual stimuli of either headphones or sunglasses on the level to which they helped them feel autonomous and connected and on how aesthetically pleasurable they were. Results show that both a product's level to express someone's autonomy and level to express connectedness positively influence aesthetic pleasure for visual product designs. Concluding, a visual product design is aesthetically pleasurable when people perceive that a product design may help in fulfilling their inherent social needs.

◆ **Errors in visual search lead to devaluation of stimuli**

15 A Chetverikov (Saint Petersburg State University, Russian Federation;
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People automatically monitor and evaluate their performance in visual tasks, and this process is closely associated with negative affect (Luu et al, 2000 *Journal of Experimental Psychology* 129 43–60). I tested the hypothesis that this meta-cognitive monitoring will influence the preference ratings for target and distractor stimuli. In the first experiment participants located target face in a circular array of faces presented for 600 or 1200 ms. Targets were specified by sex and tint (blue or yellow). After the answer participants evaluated target and distractors. The results indicated that (1) distractors were evaluated less positive than targets, and (2) stimuli were rated worse in case of incorrect answers. In the second experiment I used more complex stimuli. The miniature paintings were presented for 1600 or 2200 ms; target was specified by type (portrait or landscape) and by plus or minus symbol. Only the effect of answer correctness was replicated, but it was moderated by participants' overall accuracy. It is argued that as the exposure time was fixed, accurate participants have had to make additional effort to concentrate on target after it has been located. This, in turn, leads to target devaluation and the observed interaction. [Supported by RFBR grant #11–06–00287a.]

◆ **Six tea-towels, one calendar and 1659 children's self-portraits: A developmental study of children drawing faces**

16 C McManus, R Chamberlain, C Christopherson, L Prince-Mobbs, M Robinson, I Stelk (University College London, UK; e-mail: i.mcmanus@ucl.ac.uk)

Children and adults typically do not draw faces accurately, the commonest error being that the eyes are placed too close to the top of the head, instead of veridically at about halfway down the head. This study looked at 1659 full-frontal self-portraits which were drawn by children aged 3 to 10 in a London primary school during the autumn of 2007–10 and printed in a calendar or on tea-towels and sold for fund-raising at Christmas by the Parent-Teacher Association. Additionally, 81 self-portraits drawn by adult teachers were also available. The positions of 24 landmarks from eyes, ears, nose, mouth and head outline were digitised from photographs and used for statistical analyses. Comparative, normative data from real heads were obtained from the Farkas and Munro anthropometric data used in paediatrics. With increasing age, the drawn heads became more oval, and eyes and nose were placed lower, although the mouth stayed at the same relative position. Eyes also became wider and more oval, the corners of the mouth turned up less, and the ears were placed higher in the head. Although drawings became closer to the proportions of actual faces, even in adults the eyes continued to be placed too high.

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◆ **Viewing distance and angle matter in the Poggendorff illusion**

- 17 O Daneyko, D Zavagno, N Stucchi (Università di Milano-Bicocca, Italy; e-mail: daniele.zavagno@unimib.it)

In a previous study (Daneyko et al, 2011 *i-Perception* 2 503–507) we argued that the geometrical misalignment of two parts of the long cross in the Byzantine mosaic known as Lunette of San Lorenzo (Ravenna) is related to the Poggendorff illusion, which induced the artist to prefer a perceptual adjustment over a geometrical one. However, the geometrical misalignment was greater in the original mosaic than the average alignment determined by participants to our previous experiment. In the present work we addressed this difference by projecting a silhouette rendering of the mosaic on a large screen, simulating both size and height of the saint viewed from ground level. Participants were asked to align one end of the cross to the other end from two different viewpoints: (1) from a distance of 50 cm frontoparallel to the projection, and (2) from a distance of 750 cm, 450 cm below the projection. Results from condition 1 were similar to those obtained in our previous experiment, while results from condition 2 are consistent with the geometrical misalignment of the original mosaic. Our findings support the hypothesis that the artist was aware of the misalignment illusion, noticed when he inspected the mosaic from ground level.

◆ **The inner scribe: A role for visual short-term memory in observational drawing?**

- 18 R Chamberlain¹, C McManus¹, H Riley², Q Rankin³, N Brunswick⁴ (¹University College London, UK; ²Swansea Metropolitan University, UK; ³Royal College of Art, UK; ⁴Middlesex University, UK; e-mail: chamberlainrebeccas@gmail.com)

Enhanced visual perception is critical for successful observational drawing (Kozbelt, 2001 *Visual Cognition* 8705–723). However, the importance of visual memory (VM) in observational drawing remains under dispute. Empirical evidence suggests that there is a correlation between performance on incidental long-term visual (VLTm) memory recall and drawing accuracy (McManus et al, 2010 *Psychology of Aesthetics, Creativity and the Arts* 4 18–30). Conflicting evidence suggests that maintenance of visual information during drawing is circumvented by a more direct perceptual system, as artificially lowering gaze frequency affects drawing accuracy (Cohen, 2005 *Perception & Psychophysics* 67 997–1009). The former link between VLTm and drawing ability may be explained by the role of VLTm in online scene perception and enhanced perceptual analysis (Hollingworth, 2004 *Journal of Experimental Psychology: Human Perception and Performance* 30 519–537) rather than in the ongoing maintenance of visual stimuli, thereby resolving this conflict. However, evidence of a connection between visual short-term memory precision (VSTm) and observational drawing could not be explained in the same manner and would be suggestive of a role for VM above and beyond perceptual guidance. Short-term reproduction and delayed match-to-sample paradigms using simple geometric shapes and line pairs were used to test this contention. The results of these studies are discussed in relation to recent findings that reveal an encoding advantage for expert artists (Glazek, 2012 *Psychology of Aesthetics, Creativity and the Arts*, online first).

◆ **Evaluation of graffiti/art in different contexts**

- 19 A Gartus, H Leder (University of Vienna, Faculty of Psychology, Dept of Basic Psychological Research and Research Methods, Austria; e-mail: andreas.gartus@univie.ac.at)

According to the model of Leder et al (2004 *British Journal of Psychology* 95 489–508), the pre-classification of an image as an object of aesthetic interest is a necessary pre-condition of the aesthetic process. This requires adequate context variables like eg the appearance in a museum or an art gallery. In this work we investigate the influence of the presentational context on some aspects of the process of aesthetic appreciation. We presented graffiti / street art and more established artworks to our participants—either integrated in a street or in a museum scene. The participants were asked to rate these pictures (without scene context) on the three 7-point scales “liking”, “interest” and negative to positive “emotion”. We found a significant interaction of context type and interest in graffiti (assessed by a questionnaire prior to the experiment) for the third scale (“emotion”). That is, participants with high interest in graffiti reported a more positive emotion than participants with low interest in graffiti when the stimuli were presented in the street context (vs the museum context). These results suggest that different presentational contexts can indeed have different effects depending on individual attitudes towards the stimulus types.

POSTERS: COGNITION

◆ Cerebral hemispheric lateralization in the processing manner of verbal and spatial information

20

S Nagae (Dept of Psychology, Fukuoka University of Education, Japan;
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The purpose of this experiment was to investigate whether there were handedness and sex differences in the processing manner of verbal and spatial information. The participants were asked to see nine 5 × 5 matrices, in which six and eight hirakana letters (Japanese cursive characters representing spoken syllables) appeared, and to recall the letters, the positions of letters, or both the letters and the positions. The results of the letters and positions recall test indicated that handedness, sex, and target interaction was significant. The recall of positions by left-handed males was less than that by right-handed males, and less than recall of letters by males. The recall of positions by left-handed females was less than recall of letters by females. The results indicated that left-handed males were inferior to right-handed males in terms of the abilities of information processing, whereas females, both left- and right-handers, perform the recall of letters and positions equally well. These findings were discussed in terms of cerebral hemispheric lateralization referring to handedness and sex.

◆ A study on the temperature metaphor of happiness

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Happiness is frequently referred to in terms of warm-related metaphors. The Theory of Conceptual Metaphor (Gibbs, 1994; Lakoff and Johnson, 1999) posits that while metaphor is reflected in language, it is primarily a cognitive tool that people use to understand superficially dissimilar and concrete concepts that facilitates comprehension. The study examined whether the abstract concept of happiness is grounded in physical experience of temperature. Participants were asked to categorize happiness-related and control words as they appeared upon a background image suggestive of either warm or cold temperatures. Happiness-related words were categorized more quickly when presented upon the warm background, relative to the cold background. Background Type had no influence on categorization times for control words. Visual cues of warmth facilitated happiness-related conceptual processing. The study demonstrates that the abstract concept of happiness is grounded in physical experience of temperature. These findings are consistent with the embodied view of cognition and support the notion that conceptual thought consists of representations built on concrete sensory information (Barsalou, 1999, 2008; Lakens, 2010; Wang and Lu, 2011). References: Barsalou, L. W. (1999). *Perceptual symbol systems. Behavioral and Brain Sciences*, 22(4), 577–609. Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, 59, 617–645. Gibbs, R. W. (1994). *The poetics of mind: Figurative thought, language, and understanding*. Cambridge, England: Cambridge University Press. Lakens, D. (2010). Abstract concepts in grounded cognition. Utrecht University. Lakoff, G., and Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought*. New York: Basic Books. Wang, Z., and Lu, Z. Y. (2011). A Study on the Metaphor of Social Exclusion from Embodied Cognition. *Scientific Research and Essays*, 6(10), 2225–2227. [Acknowledgment: The research was supported by Natural Science Foundation of Hebei Province (Grant No. C2012205046) to Zeng Wang.]

◆ Looking and referring in a collaborative artistic task

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We propose a method to study gaze direction as related to joint activity in a collaborative task. Participants in pairs, each sitting in front of a display, were instructed to decorate an item in the shape of a mitten so that the two similar halves make a whole. Three mitten “halves” and 10 colors were available for each participant. The participants were encouraged to communicate. The efficiency of the participants’ activities was estimated by experts who based their judgments on correct selection of half-mitten size and orientation by the participants and on similarity of design of the two “halves” of a mitten. We used two eye trackers to register gaze direction of the participants. Their conversation was also recorded. Special software was developed for synchronous data collection. Reach communicative phenomenology elicited by the experimental design was analyzed to find relations between the participants’ efforts

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to coordinate their activities and their eye movements. Among our findings are anticipation fixations in both “speaker” and “listener”, episodic coordination of areas of interest, specific coordination of phrasing and words used by the participants with gaze direction. [We are thankful to RFH for support, grant # 11-06-01176a.]

◆ **Is a detection of gaze direction of a person in front affected by the presence of persons in the peripheral view?**

23 M Takai¹, S Eifuku², M G Kamachi³ (¹Graduate School of Engineering, Kogakuin University, Japan; ²University of Toyama, Japan; ³Kogakuin University, Japan; e-mail: ersk1106@gmail.com)

Some studies have identified the characteristics of the human perception of gaze direction (HPGD) in a setting where a target person is sitting in front of a participant. However, little is known about the characteristics of HPGD in more natural settings, such as with or without other people near the target person. In this study, we investigated a participant's HPGD to a person in front, with a varying number of people (stimuli) facing him/her: one (target person only), two (target person and someone to his/her left or right), and three (target person with one person on either side). We used a 3D-CG model of the stimuli showing controlled gaze directions. We conducted two experiments, one with the distance between the target person and the other people being 7.5° (near condition) and one with the distance being 15° (far condition). We found that the participant's HPGD to a person in front was not affected by the existence/nonexistence of people in the peripheral view nor the distance between the target person and the other people. In addition, the averted or direct gaze of the non-target people did not have any effect on the HPGD.

◆ **Violation of the Leggett-Garg inequality in visual process**

24 F T Arecchi¹, A Farini², N Megna², E Baldanzi² (¹University of Firenze and CNR-INO, Italy; ²CNR-INO, Italy; e-mail: alessandro.farini@ino.it)

The Leggett and Garg Inequality (LGI) (Leggett and Garg 1985 *Phys Rev Lett* **54** 857–860) is a test of the classical behavior of an observed system, in the case of a single measurement channel monitored at different times. LGI is based on two assumptions, both necessary, namely, macrorealism and non-invasive measurement (NIM). We report LGI violation in cognitive tasks consisting in the identification of mutually incompatible “words” with negligible semantic content: as a first attempt we have studied the Necker Cube, a well-known bistable image; the violation is maximal at an inter-stimulus time τ_{LG} around 2 sec, close to, but consistently lower than, the characteristic times associated with other, semantically rich, linguistic endeavors. The LGI violation persists over a time window of 1 sec around τ_{LG} ; outside this window NIM is recovered.

◆ **Shape (ratio of height to width) of an object affects visual weight estimation**

25 T Yoshizawa, K Takahashi, T Kawahara (Kanazawa Institute of Technology, Human Information System Laboratory, Japan; e-mail: kawa@his.kanazawa-it.ac.jp)

Visual information is a powerful cue for an estimation of object weight before a tactile measurement. For instance, a bigger object seems to be estimated to be lighter than a smaller object, of which physical weight is the same as that of the bigger one. We, therefore, aim to know a basic property of effects of visual information, especially shape information, on the estimation of object weight. Our observers (twenty undergraduates) who consented to the experiments answered which of two juxtaposed objects was heavier visually. We measured the probability that the observers chose as a heavier object, as a function of a ratio of height to width of an object. The ratio of a reference stimulus was constant at 1.0 and that of a test stimulus was varied from 0.7 to 2.5. The probability of the object whose ratio was approximately 2.0 was lower than 20%. That is, most of the observers estimated that such object was the lightest visually. This proportion does not correspond with the Golden ratio, which has been debated on issues associated with Greek architecture and sculptures in terms of their aesthetic. Although there is no scientific relation between them, our results indicate that shape information affects weight estimation of objects.

◆ **The role of low spatial frequencies in the hemispheric processing for metric properties of objects**

26 A Saneyoshi¹, C Michimata² (¹Teikyo University, Japan; ²Sophia University, Japan; e-mail: a-sane@main.teikyo-u.ac.jp)

Right handed participants performed two object-matching tasks for novel objects consisting of three geons. For each original stimulus, categorical and coordinate transformations were applied to create

comparison stimuli. In the categorical transformation, a geon connected to geon A was moved to geon B. In the coordinate transformation, a geon connected to geon A was moved to a different position on geon A. These stimuli were low-pass filtered by the filter with 2D Gaussian envelope. The Categorical task consisted of the original and the categorically transformed objects. The Coordinate task consisted of the original and the coordinately transformed objects. The non-filtered stimulus image was presented on the center of the CRT monitor, followed by a comparison object presented to the right or left visual half-fields (RVF and LVF). The results showed an RVF-left hemisphere (LH) advantage for the Categorical task and an LVF-right hemisphere (RH) advantage for the Coordinate task. Furthermore, the LVF-RH advantage for coordinate task was eliminated by the removal of low spatial frequencies information from object image. These results suggested that the processing of low spatial frequencies is responsible for the LVF-RH advantage for the metric properties processing in object recognition.

◆ **Visualization of information of a Japanese onomatopoeia**

27 Y Kiritani, K Suzuki, Y Tamagaki (Chiba University, Japan; e-mail: kiritani@faculty.chiba-u.jp)
Purpose of the present study is to reveal real figures of a Japanese onomatopoeia, "Pyon". Japanese has many onomatopoeias, so that this is a feature of the language in comparison with Western languages (Ishibashi, 2007; Yoshimura, 2007). For instance, Japanese uses onomatopoeias to communicate nuances of action or motion. It can be possible, because Japanese users have a common ground of understanding of onomatopoeias. Japanese onomatopoeia "Pyon" usually expresses bound, hopping, or jump. In the present study, participants move a wooden small cube to express "Pyon" movement. An independent variable is cube's lightness, because its apparent weight may affect its movement. There are two lightness levels, white and black. Besides this condition, an effect of accessory to express rabbit and frog is also examined. Dependent variables are distance (horizontal distance), height (vertical distance) and distance to the top (horizontal distance). Although a preliminary experiment showed an individual difference of these values among participants, most trajectories of movement were smoothly parabolic to suggest the common ground of onomatopoeia. The main experiments will introduce new variables to properly express the movement of "Pyon". Demonstration of transition from "Pyon" to other onomatopoeia to express movement like "Byoon" will be also useful.

◆ **Stroop, Simon and the separation of response keys**

28 M Jonas¹, C Bätge², O Elok¹, V H Franz¹ (¹University of Hamburg, General Psychology, Germany; ²University of Hamburg, Dept of Psychology, Germany; e-mail: melanie.jonas@uni-hamburg.de)

The recent finding that in a Stroop task, increasing physical distance between response keys attenuated color-word interference in reaction times (RTs) (Lakens et al, 2011 *Psychological Science* 22(7), 887–890) might have extensive implications for psychological experiments. It suggests that perceiving the space between response keys alone leads to spatial coding of categories that are unrelated to space (eg colors). However, participants might have been biased towards mapping categories onto space because Lakens et al displayed response key assignments in a spatial arrangement while testing. Eliminating this confound in a previous replication experiment, we found Stroop interference to be unaffected by key distance. The present study further investigates the potential interaction between spatial stimulus characteristics and key distance. In another Stroop task we presented letter strings centrally or lateralized to either side of the display. Twenty participants responded to the colors via differently spaced keys (separated by 6 or 108 cm). Whereas both color-word congruence and congruence of stimulus-response position influenced RTs significantly (Stroop- and Simon-effect, respectively), key distance again had no effect. This suggests that spatial separation of response keys alone does not necessarily interfere with the mental representation of categories.

◆ **The effect of visual information on a sense of being together in a virtual environment**

29 W Teramoto¹, N Asai² (¹Muroran Institute of Technology, Japan; ²Kyoto Bunkyo University, Japan; e-mail: teramoto@csse.muroran-it.ac.jp)

This study investigated the effect of visual information on a sense of being together in a virtual environment by using the social Simon paradigm (Sebanz et al, 2003 *Cognition* 88 B11-B21). In this paradigm, one participant presses a key in response to one colour, and the other participant presses another key in response to the other colour. Despite the fact that each participant is performing a go/no-go task, an effect similar to a standard Simon effect occurs if they feel a sense of being together. In the present experiment, a pair of participants in different rooms observed the same virtual environment through head-mounted displays and performed the task. In one condition, the participants had a 3-min

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session to interact with their co-actor in the virtual environment before the start of the experimental session and could see a co-actor's avatar throughout the session. In the other condition, the participants also could see a co-actor's avatar but did not have time to interact with their co-actor. The results showed that the social Simon effect occurred only for the former condition, suggesting that online visual information is not sufficient to evoke sense of being together in a virtual environment.

◆ **Experiencing physical warmth promotes happiness**

- 30 Z Wang¹, Y Yuan², J Zhang², W Dong², L Li², Y Su², J Wu³, J Sun¹ (¹Dept of Psychology, School of Education, Hebei Normal University; Dept of Education, Shijiazhuang Preschool Teachers College, China; ²Dept of Education, Shijiazhuang Preschool Teachers College, China; ³Medical Imaging Center, Hebei Provincial People's Hospital, China; e-mail: sunjilin2020@yahoo.cn)

Happiness is one of the abstract and social perceptual concepts. We hypothesized that mere tactile experiences of physical warmth (or coldness) would increase feelings of happiness (or unhappiness), without the person's awareness of the influence. In the study, participants who briefly held a cup of hot coffee judged the target person as being significantly happier than those who briefly held a cup of iced coffee. The result suggests that physical warmth increases feelings of happiness. The finding is consistent with the embodied view of cognition and support the notion that social perception involves physical and perceptual content (Barsalou, 1999 *Behavioral and Brain Sciences* 22(4), 577–609; Barsalou, 2008 *Annual Review of Psychology* 59 617–645; Lakens, 2010 Abstract concepts in grounded cognition. Utrecht University; Wang and Lu, 2011 *Scientific Research and Essays* 6(10), 2225–2227). [Acknowledgment: The research was supported by Natural Science Foundation of Hebei Province (Grant No. C2012205046) to Zeng Wang.]

◆ **View dependencies in the visual recognition of social interactions**

- 31 S de La Rosa, S Miekens, H Bülthoff, C Curio (Max Planck Institute for Biological Cybernetics, Germany; e-mail: stephan.delarosa@gmail.com)

Humans daily physically interact with other people (eg when shaking hands). Understanding the action of others is important for a successful social interaction. Little is known about the visual processes underlying the visual recognition of social interactions. Here we were examined the view dependency of social interaction recognition. We used motion capture to record predefined interactions (eg high five; handshake; hug) acted out by pairs of participants and created 3D models of these interactions. In the actual experiment participants were presented with these interactions one at a time and had to identify a predefined interaction (IIFC task). We manipulated the view point (front, side, top, 45 degree side view) from which participants saw the interaction and the presentation time of the social interactions. We recorded participants' accuracy (as measured by d prime) and reaction time to identify a predefined social interaction. We found that the d primes and reaction time significantly depended on the view point of the social interaction. The results suggest the existence of view dependencies in the visual recognition of social interactions. [This research has been supported by the EU project TANGO (FET-Open grant number: 249858).]

◆ **Rapid extraction of holistic meaning from visual displays of multiple words**

- 32 N Sakuma¹, E Kimura², K Goryo³ (¹Graduate School of Sciences and Technology, Chiba University, Japan; ²Dept of Psychology, Faculty of Letters, Chiba University, Japan; ³Faculty of Human Development and Education, Kyoto Women's University, Japan; e-mail: n-sakuma@graduate.chiba-u.jp)

When a set of meaningful symbols (eg, numerals and Japanese Kanji characters) is briefly presented, it can be processed much more efficiently than a set of ordinary letters such as alphabets (eg, Sakuma et al, 2009 *Perception* 38ECVP Supplement, 150). We extended this finding with two-character Kanji words and found that holistic affective valence could be rapidly extracted from a set of spatially-distributed words. We presented a visual display containing two sets of 9 different words for 200 msec. Each word had either negative or positive affective valence. The proportion of positive to negative words and the frequency of use of the words were manipulated in each set. The observer's task was to determine which set was holistically more positive (or negative). The results showed that observers could efficiently and reliably indicate the correct set. This finding was not attributable to simple word counting because observers could not fully identify individual words in the set. Moreover, the performance was greatly modulated by word frequency; more frequently used words were processed more efficiently. Some observers even identified the set composed of fewer positive (or negative) words as more positive (or negative), when the fewer were frequently used words.

◆ **Mere exposure effect for amodally completed stimuli**

33 A Tomita¹, S Matsushita², K Morikawa¹ (¹Osaka University, Japan; ²Ritsumeikan University, Japan; e-mail: a-tomita@hus.osaka-u.ac.jp)

The mere exposure effect (MEE) refers to the phenomenon where repeated exposure to a stimulus results in increased liking for that stimulus. When a shape is partly occluded, observers usually perceive the contours to be continuous (ie amodally completed) behind the occluders. This study investigated whether the MEE would generalize to amodally completed perceptual representations. We used novel abstract shapes as stimuli, which were overlaid with square-wave grating occluders (ie stripes) of various widths. In the exposure phase of experiments, 50%-occluded shapes were repeatedly presented to observers. In the rating phase, observers rated the likeability of the same 50%-occluded stimuli, non-occluded stimuli that had not been presented, and stimuli 50%-occluded by gratings which were half-cycle shifted. The results indicated a significant MEE only for exactly the same 50%-occluded stimuli. Another experiment confirmed that observers actually perceived amodal completion in those stimuli. It is shown that the MEE for partly occluded stimuli does not generalize to amodally completed perceptual representations. Stimuli 50%-occluded by finer gratings are perceptually indistinguishable from stimuli occluded by half-cycle shifted gratings. The present study suggests that the visual system can still distinguish them at the level of affective preference.

POSTERS: COMPUTER AND ROBOT VISION

◆ **Assessing an image processing model of edge visibility with a psycho-visual experiment**

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An image processing simulation of the human visibility could be a valuable tool for a large spectrum of applications. We have developed a computational model which computes the visibility of edges in an image for a human observer (Joulan et al, 2011, CVPR workshop on Biologically-Consistent Vision, Colorado Springs, 33–38). From this model, we compute the visibility as the ratio between contrast and contrast detection threshold, on the objects' edges. To assess the model predictions with respect to human performance, a psycho-visual experiment was performed on a detection task with 30 subjects. Four stimuli (discs and annulus with 1° and 0.2° in diameter) of various contrasts were displayed during 200 ms. The 50% detection rate was computed by fitting the experimental data with a Weibull function, and compared to the model's predictions. We found a good quantitative agreement for the discs, while the model underestimates the rings' visibility. These results suggest a new model, computing the object's visibility from the accumulation of local visibility indexes, rather than from their maximum.

◆ **The role of nonlinearities in hierarchical feed-forward models for pattern recognition**

35 S Eberhardt, T Kluth, M Fahlé, C Zetzsche (Universität Bremen, Germany; e-mail: sven2@uni-bremen.de)

Hierarchical feed-forward models for pattern recognition have been proven to be plausible in explaining receptive field properties of neurons in the ventral stream of primate visual cortex. In particular, the HMAX-model presented by (Serre et al, 2007 *Proceedings of the National Academy of Sciences of the USA* **104** 6424–6429) can account for psychophysical results in rapid object categorization experiments by using alternations of matching and pooling layers. However, it is still unclear which nonlinearities are required in layers to perform pattern recognition tasks. Here, we developed a generalized form of the HMAX model in which we systemically varied the nonlinearities at each layer in the hierarchy between specificity and invariance using a control parameter. We evaluate the resulting model on several classification tasks and show that classification performance depends on the choice of control parameters for individual layers. Second, during a learning phase, we fed videos of natural scenes into the model and used both principal component analysis and slow feature analysis to extract components from feature space at different levels of the processing hierarchy. We show how the control parameters affect the extracted components and draw conclusions on how layers need to be arranged in an optimal feed-forward architecture for pattern recognition in natural scenes.

◆ **An a-contrario model for predicting perceptual thresholds in contours detection**

36 S Blusseau, J Lezama, R Grompone, J Morel (CMLA, ENS Cachan, France; e-mail: grompone@gmail.com)

This communication bridges a gap between computer vision methods and classic psychophysical setups. The non-accidentalness principle is invoked in psychophysics to explain the emergence of percepts. The mathematical theory of a contrario detection formalizes this principle (Desolneux, Moisan, Morel,

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2008 in *From Gestalt Theory to Image Analysis, a Probabilistic Approach*, Springer) and attempts to predict ideal perception thresholds. Thus, it is natural to reconsider from a computational perspective, classic and new psychophysical experiments evaluating the human perception performance. To this aim, we chose the psychophysical experiments by Wagemans et al (Nygård, Van Looy, and Wagemans, 2009 *Vision Research* **49**(20), 2475–2484) where subjects are presented with Gabor-rendered outlines of real world objects. In these experiments, orientation jitter was added to the elements with the aim of determining its effect on human object detection performance. Using the a contrario theory, the human detection thresholds can be compared rationally to the algorithmic ones. To allow a broader experimentation, we built an online web facility where users can perform object detection experiments, and compare their detection curves to the ones predicted analytically by the computational model.

◆ **A motion feature-based algorithm for the detection of specular objects in natural scenes**

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Successful identification of specularities in an image can be crucial for an artificial vision system when extracting the semantic content of an image or while interacting with the environment. We developed an algorithm that relies on scale and rotation invariant feature extraction techniques and uses motion cues to detect and localize specular surfaces in an office scene. Appearance change in feature vectors is used to quantify the appearance distortion on specular surfaces, which has previously been shown to be a powerful indicator for shininess (Doerschner et al, 2011 *Current Biology* **21**(23), 2010–2016). The algorithm combines epipolar deviations (Swaminathan et al, 2002 *ECCV* 167–172) and appearance distortion cues and succeeds in localizing specular objects across a wide range of camera motions and speeds, object sizes and shapes, and performs well under image noise and blur conditions.

POSTERS: DECISION MAKING

◆ **Optimising strategies on the numberline task**

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The ability to correctly indicate the location of a numerical magnitude on a linear scale, the numberline task, has frequently been measured as a proxy for mathematical abilities. There are several caveats to this measure, particularly when using digits, as learning and cognitive strategy appear to play a large role in performance. Here we parametrically examined a variety of numberlines—differing in scale, direction, length and the origin and endpoint of magnitudes covered—to identify various different sources of error. Furthermore we utilised dot clouds as well as digits to identify differences in behaviour between estimated and absolute numerosity judgments respectively. Overall the various numberline perturbations were best explained by a modified performance-optimizing Bayesian model, where judgment errors were minimised by incorporating a prior, defined by a probability density function comprising a combination of physical features of the numberline, particularly its endpoint and centre. Little evidence supported the notion of “logarithmic coding”. These results demonstrate the presence of non-numerical optimising strategies on the numberline task, which have implications for subjects with difficulties in mathematics, where poorer performance may correlate with difficulty in applying an optimal strategy.

◆ **How children deal with risk in a visuomotor task**

39 T Dekker, J Jones, M Nardini (University College London, UK; e-mail: tes.m.dekker@gmail.com)

Human adults can take uncertainty in their sensory and motor systems into account to maximize gain in rewarded visuomotor tasks. It is unclear when or how humans learn their own sensory and motor capabilities, or become able to use this information to make optimal decisions under risk. To explore the development of these abilities, we applied a Bayesian decision-making framework that captures adults' movement strategy choices (Trommershäuser et al, 2003 *Journal of the Optical Society of America A* 1419–1433) to a child-friendly, rewarded visuo-motor task. Six- to 11-year-old children and adults earned points by rapidly touching a target on a screen, while avoiding a partially overlapping penalty region. Spatial configurations of the penalty and target and penalty size were varied. To choose the gain maximizing-strategy in each condition, subjects must represent and take into account their own visuo-motor uncertainty. Adults chose movement strategies close to those maximizing expected gain in response to changes in penalty location and size. Children showed changes in strategy when risk was introduced, but selected pointing strategies that were further from optimal. These results suggest that

optimal decision making under risk takes surprisingly long to develop. Children may have inaccurate representations of own variability, of probability, and/or of value in the task.

◆ **Saccade trajectory of a perceptual decision is influenced most by the last evidence viewed**

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Where to saccade is a frequent perceptual decision. Research using random dot kinematograms (RDKs) shows increasing motion coherence indicating a choice leads to saccade trajectory deviating further away from the non-selected target (McSorley and McCloy, 2009 *Experimental Brain Research* **198** 513–20). Here, we examine whether the temporal window over which participants integrate information affects saccade metrics. The window is ~100ms; when useful information is presented after this, performance falls to chance (Ludwig et al, 2005 *Journal of Neuroscience* **25**(43), 9907–12). Participants made a saccade to the target indicated by motion within an RDK, which contained a window of high coherence information among random motion, the position of which varied along the trial. It was hypothesised that when the window was at the beginning of the trial, there would be increased deviation away from the non-selected target and better performance as it would be incorporated into the decision. There were no differences in performance or saccade metrics. A second experiment carried out detailed analysis of the timings. Performance did not vary, but saccade trajectory deviated away significantly more when the window was at the end of the trial. This suggests the final evidence has the most impact on saccade trajectory.

◆ **Integration of extraretinal and visual information for perceptual decisions across eye movements**

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We continuously move our eyes when we inspect a visual scene. For the successful integration of visual information into a coherent scene representation the visuomotor system needs to deal with these constant self-induced perceptual changes and distinguish them from external motion. Internal forward models may help to solve this problem: The brain may use an internal monitoring signal associated with an oculomotor command to predict the visual consequences of the corresponding eye movement and compare this prediction with the actual perceptual outcome. Space integration across eye movements has been classically studied in sparse visual environments. However, visual scenes in everyday life typically contain a rich structure of spatial relational information, providing additional cues to disambiguate self-induced from external changes of perceptual input. We asked normal subjects to perform a simple perceptual decision on the apparent displacement of a visual target, jumping unpredictably in sync with a saccadic eye movement. In a critical test condition, the target object was presented together with flanker objects. Perceptual decisions in this condition could also take into account the spatial distance between target and flankers. Results support the notion that subjects combine internal monitoring and visual relational information in an efficient manner, weighting these information sources depending on their respective reliability.

◆ **What happens early in ultra-rapid object recognition?**

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Human observers are remarkably fast in detecting animals in complex natural scenes. One possible explanation is that fast visual recognition may rely on the sequence of cortical arrival times of spikes according to a temporal order code. We tested this possible explanation by scrambling temporal scene information, distributing image presentations on pixel by pixel basis on several consecutive frames at high presentation rate (150 Hz) while keeping overall image information constant. Stimuli were presented at a CRT screen for up to 100 ms, separated in maximally 15 frames, and subjects in a first experiment pushed one of two buttons to indicate, in a 2AFC task, whether the image to the left or else in the one to the right of the fixation point contained an animal. Participants responded by a saccade in the second experiment, with or else without a temporal gap between fixation point and stimulus presentation. We did not find significant differences in overall reaction times and performance levels between simultaneous versus temporally scrambled presentations, and only performance of less frequent ultra-fast responses declined moderately as a function of early image content, not supporting the notion of a general use of cortical arrival times for pattern recognition.

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◆ **Effect of gender membership on sequential decision of face attractiveness**

43 A Kondo, K Takahashi, K Watanabe (The University of Tokyo, Japan;
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When we make decisions for sequentially presented items, each decision is biased by the stimulus and decision in the preceding trials (the sequential effect; Holland and Lockhead, 1968 *Perception & Psychophysics* 3 409–414). In a mixed-category sequence, the sequential effect is stronger when the stimuli of current and preceding trials fall under the same category (Ward, 1985 *Perception & Psychophysics* 38 512–522). In the present study, we investigated whether the gender membership of faces would affect on the sequential effect. Forty-eight pictures of male and female faces were presented successively. Participants rated attractiveness, roundness, or intelligence of each face on a 7-point scale. The sequential effect was observed irrespective of the property to be judged. However, the sequential effect was enhanced in the same-category trials only for the attractiveness judgment, not for the roundness judgment or the intelligence judgment. These findings suggest that the gender of faces serves as a cue for forming category representation when face attractiveness is of interest, and hence the category formation in sequential decision is adaptive process depending on the property to be judged.

◆ **How different choice methods affect perceptual decision bias**

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Decisions based on visual patterns are not only based on immediate visual signals but also on the observer's knowledge about what is likely to be shown. Perceptual decision making is thus not purely perceptual. It has been found that such bias is observed differently in 2AFC and 2IFC tasks in terms of time span within which past information is accumulated, even when experimental settings are identical except that the instruction to the subjects were given accordingly (Kim et al 2009 *Journal of Vision* 9(8) 827). The results show that while a decision as to when an event happens is partially determined by immediate past events, a decision as to what feature is presented is determined by an accumulation of longer past experiences, suggesting different mechanisms underlying those two types of tasks although they are statistically identical. Here we propose a probabilistic model based on a diffusion model that can explain the difference effectively in terms of both short-term and long-term aspects of the decision process. The model indicates that different decision thresholds would underlie the observed different biases. We also discuss how this difference may affect experimental designs in general.

◆ **Time scale of evidence integration in visual motion decisions**

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Current computational models of perceptual decisions postulate that choices are based on the temporal integration of sensory information. When the stimulus duration is controlled by the environment, the optimal strategy is to integrate all the evidence provided. We tested whether human observers do so during judgments about the net motion of random dot kinematograms. We presented random dot kinematograms for various durations and at various levels of motion strength and computed psychophysical thresholds for each stimulus duration. The time scale of perfect integration was estimated as the duration, for which thresholds decrease with stimulus duration with a slope of approximately -0.5 in log-log coordinates. We compared the integration time scale across different 'task sets': yes-no motion detection and up/down motion discrimination; up/down discrimination with fixed stimulus-response (SR) mapping and with trial-to-trial variations in SR mapping. Under fixed SR-mapping, observers integrated information nearly perfectly across at least 3 s. Further, the integration time scales were independent of discrimination/detection, but time scales decreased (to ~ 500 ms) when the SR mapping varied from trial to trial. We conclude that the integration time scale in perceptual choice, can be long, dependent on the automaticity of the SR mapping. This dependence may reflect capacity limits.

◆ **Temporal integration in visual motion detection with temporal uncertainty**

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Computational models postulate that perceptual choices are based on the temporal integration of sensory signals. So far, this computation has commonly been probed in tasks, in which the level of sensory

evidence is constant. However, in natural environments sensory evidence varies in an unpredictable fashion. We characterized how humans integrate coherent random dot motion signals embedded in a stream of flickering noise (0% motion coherence), introducing temporal uncertainty about the start of the signal. Motion signals of varying duration (between 120–960 ms) and coherence levels occurred at random latencies within a 4 s noise stream, or not at all (25% of trials). In different conditions, blocked by session, signal durations were mostly short (120 ms) or mostly long (960 ms). Subjects' detection thresholds decreased monotonically as a function of signal duration up to 960 ms, consistent with temporal integration even under temporal uncertainty. The dependency of the integration timescale on the presence of temporal uncertainty and the prevalent stimulus duration will be examined by means of a simple computational model of the decision process.

◆ **The estimation of short durations and an objective measure of observer performance evaluation**

47 S Cropper¹, A Johnston², A Bruno² (¹University of Melbourne, Australia; ²University College London, UK; e-mail: scropper@unimelb.edu.au)

We examined observers' ability to judge short durations and then reflect upon their own performance. Observers responded to 2 identical presentations of a drifting sine grating 4 deg above fixation. They initiated presentation with a button-press, and released the button when they considered the stimulus to be half-way through. The intervals ranged between 0.5 and 2.0 s and the duration conditions were blocked. Subjects were asked to indicate their 'most accurate estimate' of the two. Observers consistently over-estimated the true duration. This standing error was not proportional to interval length. As expected there was no significant difference in variance (or mean) between the first and second interval. When trials were grouped by objective performance the 'ideal' estimates had a significantly smaller variance. However, when grouped on observer section the 'best' estimates also had a significantly lower variance compared to the worst, indicating observer awareness of decisional noise on a trial-by-trial basis. The difference in variance between selected and rejected trial provides an objective measure of performance evaluation and an alternative to subjective confidence ratings. One implication of this study is that improved performance through perceptual learning may involved learning a model of observer noise.

POSTERS: EEG AND ELECTROPHYSIOLOGY

◆ **Effects of closure on the processing invisible figures: An ERP study**

48 W Zhu¹, Y Ma² (¹Yunnan University, Kunming Institute of Zoology, CAS, China; ²Kunming Institute of Zoology, CAS, China; e-mail: zhuweina_xm@sina.com)

The specific nature of closure is important for the computation of an object representation. The discrimination of closure is typically faster and easier than that of other geometrical features (Treisman and Paterson, 1984 *Journal of Experimental Psychology: Human Percept and Performance* **10** 12–31). In order to investigate whether the specific nature of closure required conscious perception, we recorded event-related potentials (ERPs) during a continuous flashed suppression paradigm (CFS), in which the target was displayed in one eye to compete against a flashed full contrast Mondrian pattern presented to the other eye. This method ensured that the target image was suppressed during the experiment. During most trials, the closed figures were more likely and faster to overcome the flashed suppression than open figures (469ms vs 488ms; 18.3% vs 9.6%). ERPs showed invisible closed figures to evoked greater N1 amplitude than open figures on the left temporal-parietal areas (-2.07 uv vs -1.73 uv; $t_{15} = 2.76$, $p = 0.015$) with slightly shorter latency (121.8 ms vs 129.4 ms). Visible figures induced opposite results, with closed figures evoking smaller N1 amplitude (-5.3 uv vs -8.6 uv). Our results indicate that closure can be processed in the absence of awareness, and showed a perceptual advantage of closed figures, which were more rapid and lightly to overcome flashed suppression.

◆ **Learning new faces from multiple images**

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It has been suggested that familiar and unfamiliar faces employ different processing mechanisms with familiar faces recognised via an invariant structural code and unfamiliar faces from the pictorial codes contained within an image of a face (Bruce and Young, 1986 *British Journal of Psychology* **77** 305–327). Recent research has suggested however that perhaps all faces, including familiar faces are recognised through pictorial coding (Longmore, Liu and Young, 2008 *Journal of Experimental Psychology: Human*

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Perception and Performance **34** 77–100). We present a series of experiments showing that when recognition across viewpoints (eg full-face to profile) of a face is required, recognition does indeed appear to be tied to the images studied. However, using the same experimental paradigm, evidence from ERPs indicates that there might be some degree of facilitation in learning two viewpoints (frontal and profile) when recognition on a previously unseen view (three-quarter) is required compared to learning a single view. This suggests that some kind of structural information is being extracted during learning that facilitates recognition from novel views. It would appear that whilst the behavioural data indicates a predominately pictorial basis for the recognition of newly learnt faces, neuro-correlates suggest greater levels of invariance.

◆ **Active vision plugin: An open-source MATLAB tool for saccade- and fixation-related EEG analysis**

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Although natural vision is fundamentally transsaccadic, EEG data on vision is usually recorded during fixation. An alternative approach to signal analysis, used in several recent studies (for review see Dimigen et al, 2011 *JEP:General* **140** 552–572), is to time-lock the EEG to saccade- or fixation onsets during free viewing. Recording high-resolution eye movements with the EEG is also useful for controlling fixation, detecting signal distortions from microsaccades, measuring saccadic reaction times, improving EEG artifact correction, or simultaneous pupillometry. To facilitate joint analyses of oculomotor and electrophysiological data, we present a plugin to the popular open source MATLAB toolbox EEGLAB, which parses, imports, and synchronizes eye tracking data and adds it as extra channels to the EEG. Eye trackers from SMI (IView X) and SR Research (EyeLink) are currently supported. Saccades and fixations are detected with the algorithm of Engbert and Mergenthaler (2006) or imported from the raw EDF file and then added to the EEGLAB event structure. Additionally, ICA components can be objectively selected or rejected based on their covariance with the electrically independent eye track. We exemplify usage of the plugin for an experiment in which we investigated the contribution of extraretinal signals to fixation-related potentials during visual search.

◆ **An electrophysiological investigation of attentional bias towards fearful and angry faces in a PTSD population**

51

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Evidence from probe detection tasks suggests that anxious individuals exhibit biased (enhanced) selective attention to visual threat stimuli, such as angry and fearful faces. Research has demonstrated that redirection of attentional focus can reduce fear response, suggesting that competing cognitive processes may interfere with or diminish facial expression processing. The current study used event-related potential (ERPs) to examine the effects of cognitive load on attentional bias towards ecologically threatening stimuli (emotional faces) in 20 posttraumatic stress disorder (PTSD) patients and 20 healthy controls (HC) in two tasks: a) dot-probe visual (DPV); and b) dot-probe divided-attention (DPD). DPV task required participants to respond to the presentation of the visual target (following a pair of faces), while ignoring the auditory tones. The DPD task required participants to respond to the presentation of visual and auditory targets. Both groups showed early attentional bias to angry and fearful faces as indexed by P100 and face-specific N170 visual ERP components. DPD acted to diminish attentional bias in the PTSD group. The results provide electrophysiological support for early visual attentional biases toward angry and fearful faces in PTSD and possible moderating effects of divided attention.

◆ **Electroencephalographic evidence of normal inversion effect even with impaired holistic processing in high-functioning adults with autism.**

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To determine if face processing impairment (recognition of identity, emotion, gender and age) observed in people with Autism Spectrum Disorders (ASD) result from early dysfunction of the visual ventral pathway, we measured event-related potentials in 16 typically developing controls and 7 subjects with high-functioning ASD performing a face decision task on a wide range of face and non-face stimuli. With exception of the Mooney faces, ASD subjects performed identically to controls, in the identification of photographic and schematic faces. ASD subjects showed the normal face inversion-effect, with

longer latencies and higher N170 amplitudes over occipital electrodes to inverted rather than upright photographic faces. However, a lateralization effect was found, with right hemispheric N170 amplitudes in controls higher in all face categories than in ASD subjects. The results can be interpreted in the light of current models of face processing as sparing of the first-order configural level and impairment of the higher holistic level of face processing (Maurer et al, 2002 *Trends in Cognitive Sciences* 6(6), 255–260). These results suggest that early-intermediate anomalies of the visual ventral pathway during face processing might underlie the face processing deficits detected in ASD.

◆ **The face sensitive N170 component in developmental prosopagnosia: effects of stimulus type and inversion**

53 J Towler¹, A Gosling¹, B Duchaine², M Eimer¹ (¹Birkbeck, UK; ²Dartmouth, USA; e-mail: johntowler@hotmail.com)

Individuals with developmental prosopagnosia (DP) show severe face recognition deficits in the absence of any history of neurological damage. To ascertain the time-course of atypical face processing in DP, we measured the face-sensitive N170 component of the event-related brain potential (ERP) in a group of sixteen adult participants with DP and sixteen control participants. Reliable enhancements of N170 amplitudes in response to upright faces relative to houses were found for the DP group. This effect was equivalent in size to the effect observed for controls, demonstrating face-sensitivity of the N170 component in DP. In marked contrast, most DPs showed atypical N170 face inversion effects. In the control group, N170 components were reliably enhanced and delayed for inverted faces compared to upright faces, indicative of processing differences for these stimuli. In the DP group, the difference between upright and inverted faces was absent. The absence of typical N170 face inversion effects in the DP group suggests that deficits in the structural encoding of faces are a common source of face recognition impairments in individuals with DP.

◆ **Evidence for a unified representation of faces from EEG frequency tagging stimulation**

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Behavioral studies have shown that the processing of the top half of a face is no longer influenced by the identity of the bottom half when they are spatially misaligned. However, evidence for the integration of face parts into a unified ('holistic') representation when the two halves are aligned vs misaligned is still lacking. To address this issue, we used the frequency-tagging stimulation technique during the EEG recording (Regan and Heron, 1969). Ten participants were presented with faces composed of top/bottom parts flickering at different frequencies (5.88 or 7.14 Hz). The parts could either be aligned, or spatially misaligned (5 levels of misalignment). The contiguous border between the top/bottom halves was kept constant across conditions by increasing the size of the stimulus with misalignment. The recorded EEG was transformed to the frequency domain. For the fundamental frequencies of stimulation, frequency-specific increases were found in the medial-occipital region for all conditions. Most importantly, over the right occipito-temporal channels, EEG increases were found at intermodulation terms (ie, $5.88 + 7.14 = 13.01$ Hz) for the aligned condition only. This study provides objective evidence for a unified representation of faces in the right occipito-temporal cortex.

◆ **Middle spatial frequencies elicit the same N170 amplitude as fullband images in both face and object stimuli**

55 C A Collin¹, M E Therrien¹, K W Campbell¹, J Hamm² (¹University of Ottawa, Canada; ²University of Auckland, New Zealand; e-mail: ccollin@uottawa.ca)

Previous work has shown that electrophysiological responses are greatest and face recognition performance is best when a band of middle spatial frequencies (SFs) are included in stimuli. Conversely, there appears to be less of an effect of SF filtering on object recognition. The present study examined the effects of SF filtering on the N170 ERP component as elicited by face and object stimuli. Results indicate that the amplitude of the N170 exhibits a band-pass modulation function across the SF spectrum for faces but not for objects. N170 amplitude for face stimuli is greatest for middle SFs (around 11 cycles/face), and this filtering condition shows no statistically significant difference from the unfiltered baseline condition. In contrast to faces, object stimuli elicited a relatively flat function across the lower and middle portions of the SF spectrum. However, for both faces and objects, middle SFs were sufficient to elicit the same N170 magnitude as fullband images. Indeed, the waveforms for middle SF and fullband images are virtually identical for both classes of stimuli. This may indicate that the N170

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reflects configural processing in both objects and faces, and that middle SFs are sufficient for this kind of processing in both.

◆ **Cortical excitability and effective connectivity in face processing: a TMS-EEG study**

- 56 G Mattavelli¹, L J Romero Lauro¹, M Rosanova², E Natale¹, S Romanella¹, C Papagno¹ (¹Dept of Psychology, University of Milano-Bicocca, Italy; ²Dept of Clinical Sciences, "Luigi Sacco", Università degli Studi di Milano, Italy; e-mail: costanza.papagno@unimib.it)

Neuroimaging and electrophysiological studies have shown that a fronto-temporo-occipital network is involved in face processing. However, the actual connectivity and the interactions between these areas remain unclear. Transcranial magnetic stimulation combined with electroencephalography (TMS-EEG) allows non-invasive and direct measurements of excitability and effective connectivity in the human cerebral cortex. This is the first study using TMS-EEG to explore local cortical excitability and long-range effective connectivity at rest and during different face processing behavioural tasks. Single-pulse TMS was delivered over the medial prefrontal cortex (mPFC) while face identity or face expression matching tasks at 100 ms from face stimulus onset, while continuous EEG was recorded using a 60-channel TMS-compatible amplifier. TMS-evoked potentials (TEPs) recorded during the behavioural tasks were compared with TEPs recorded during a passive point fixation and event related potentials (ERPs) evoked by the tasks without TMS. Preliminary results revealed that the behavioural tasks modified local TEPs produced by mPFC stimulation. Moreover, TMS interfered with the early EEG components in the temporo-occipital regions. These findings contribute to clarify task-related activity in the face cortical network and suggest that fronto-occipital connections are involved in the early stage of face processing.

◆ **Early neural correlates of familiarity during binocular rivalry**

- 57 B N Jack, U Roeber, R P O' Shea (Southern Cross University, Australia; e-mail: bradley.jack@scu.edu.au)

An infrequent visual stimulus—a "deviant"—yields a more negative event-related potential (ERP) 200 ms after the event than frequent visual stimuli—"standards": the visual mismatch negativity (vMMN). We sought the vMMN during binocular rivalry by presenting 80% standards—an 180° phase shift in one grating to one eye every 500 ms and the same phase shift in an orthogonal grating to the other, and 20% deviants—either by swapping the phase-shifting gratings between the eyes or by rotating them 45° to 16 participants who pressed keys to report their experiences of rivalry. We counterbalanced which stimuli were standards and deviants. We found only a more positive ERP for the standard 100 ms after the event. This is not only opposite to the vMMN, but opposite to what would be expected from adaptation. We are exploring the parameters of this finding, such as whether it is something about rivalry (by making the stimuli identical in the two eyes) or something about the task (by relieving the participant of the necessity to record rivalry). Our initial results indicate it has something to do with rivalry, possibly because its perceptual changes make deviants seem more frequent than they are.

◆ **The influence of ongoing brain oscillations on apparent motion perception**

- 58 L Sanders¹, R Auskulewicz², N Busch³, P Sterzer⁴ (¹Berlin School of Mind and Brain, Humboldt-Universität zu Berlin; Dept of Psychiatry and Psychotherapy, University Medicine Berlin, Germany; ²Berlin School of Mind and Brain, Humboldt-Universität zu Berlin, Germany; ³Institute of Medical Psychology, Charité University Medicine Berlin, Germany; ⁴Dept of Psychiatry and Psychotherapy, University Medicine Berlin, Germany; e-mail: lia.sanders@hu-berlin.de)

Several studies have demonstrated a link between ongoing oscillatory alpha activity and upcoming stimulus detection. Here we sought to investigate how prestimulus brain oscillations influence the perception of apparent motion (AM), a visual illusion that occurs when two blinking dots are perceived as one single moving stimulus. The perception of AM depends on the presentation frequency. At low presentation frequencies, the percept varies between sequential alternation and smooth movement (AM). At higher frequencies, perception varies between AM and two simultaneously flickering dots. Using stimulation frequencies at which individual subjective perception fluctuated between motion and alternation or motion and flicker, we asked participants to classify their percepts, while we recorded EEG signals. We found that the influence of prestimulus alpha power on AM perception varied with presentation frequency. At the low presentation frequency, fronto-occipital alpha power was positively associated with AM perception, whereas at the high presentation frequency, a decrease in ongoing alpha power accompanied the motion percept. In addition, prestimulus fronto-occipital phase-locking in the

alpha band was positively related to AM perception irrespective of stimulation frequency. These results point to a role of ongoing alpha power and fronto-occipital phase synchronization in the perception of AM motion.

◆ **EEG-correlates of different degrees of visual ambiguity**

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During observation of ambiguous stimuli our percept is instable. Disambiguated stimulus variants stabilize our percepts and evoke a huge positive event-related potential 400 ms after stimulus onset ("P400"). No such P400 had been found for the ambiguous stimuli. This parietal/central P400-effect was found for the geometric Necker cube and Borings semantic Old/Young woman. In the current study we tested for a P400 effect in von Schiller's stroboscopic alternative motion stimulus ("SAM") and studied whether the P400 amplitude follows a stepwise reduction of stimulus ambiguity. Methods: Participants compared consecutive geometric cube stimuli and SAM stimuli with different degrees of ambiguity and indicated perceptual reversals manually. We calculated separate ERPs for stimulus categories and degrees of ambiguity. Results: For both stimulus categories the P400 amplitude increased monotonically with decreasing ambiguity. An earlier, frontal/central ERP positivity ("P200") showed similar activity pattern. Discussion: Stimulus ambiguity—across very different categories and thus at a very abstract processing level—seems to be processed as early as 200 ms after stimulus onset and are reflected in the P200 amplitude. The P200 may reflect a subconscious evaluation of the perceptual stimulus interpretation whereas the P400 may reflect conscious access.

◆ **Cortical localization of second-order visual mechanisms**

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The aim of our investigation is to determine localization of second-order visual mechanisms. For that we used mismatches between EPs to a non-modulated texture and those textures modulated in contrast, orientation, and spatial frequency. Response to a modulated texture differs by the fact that the same operation chain is now added by the work of second-order filters. The above "inserted operation" should introduce definite changes in the EP. Each observer (20 persons) was to identify the presenting textures. EEG was recorded by 18 leads. The first step was to obtain, for each observer, EPs for 4 textures. The next step was to obtain the differences between the responses to the non-modulated texture and each of the modulated textures. The third step was connected with obtaining averaged mismatches in the whole test group for each difference and in each lead. This enabled to establish those time periods when obtained mismatches were not accidental. We entered averaged mismatches of these time periods in the EEGLAB program and localized the sources of these mismatches using functions of DIPFIT2 plugin. It was found that the mechanisms which provide perception of different modulations have not the same localizations within dorsal visual pathway.

◆ **Fixation-related potentials to faces in a free-viewing visual search task**

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The use of event related potentials (ERPs) has been almost exclusively limited to situations where eye movements are precluded. However, when subjects explore a scene or look for a target in the real world, they systematically produce discrete sequences of fixations, gathering and integrating information in each instance of the sequence. Despite the compelling contribution of ERPs and eye movements to cognitive neuroscience, to date only a handful of experiments have exploited both techniques simultaneously. In the present study we concurrently recorded EEG and eye movements in a free-viewing visual search paradigm. Subjects were asked to find a hidden target face in a crowded scene including distractor faces. We analyzed fixation-related potentials (fERPs) to target and distractor stimuli. Additionally, we compared the fERPs obtained in our free-viewing visual search task with the ERPs in an oddball control experiment performed without eye movements. Our findings show the emergence of fERP components associated with the perception of faces and the detection of targets, contributing towards a better understanding of brain activity during free viewing in real-world-like scenarios.

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◆ **Maturation of motion-onset VEPs in children**

- 62 Z Kubova, J Kremlacek, J Langrova, J Szanyi, M Kuba (Charles University, Czech Republic; e-mail: kuba@lfhk.cuni.cz)

The motion-onset VEPs (M-VEPs) display distinct age dependent changes. The latencies of their main negative peak N160 are steeply shortening up to 18 years of age and the VEPs are also changing their shape during this time (Langrova et al, 2006 *Vision Research* **46** 536–544). The aim of our study was to determine those parameters of motion stimulation that have principal influence on shape and latencies of the M-VEPs in children. M-VEPs were elicited by translational linear movement of vertical bars or checks and by radial movement of concentric circles. We changed spatial frequency of structure ($0.2\text{--}1\text{ c deg}^{-1}$), contrast of stimulus luminance (0.1 and 0.95), its modulation (sinusoidal versus square-waved) and velocity of motion (5–25 deg/s). M-VEPs to linear translation were more similar to adult M-VEPs than those to radial movement. Amplitude of N160 peak increased and its latency decreased at full square-waved contrast stimulus with higher spatial frequency. Reported M-VEPs sensitivity to stimuli parameters corresponds to slow maturation of contrast sensitivity, which should be respected during electrophysiological examination of children. [Supported by GAČR, project P407/12/2528 and Charles Univ.-Faculty of Medicine in Hradec Kralove (PRVOUK).]

◆ **Visual evoked potentials to peripheral stimulation**

- 63 M Kuba, J Kremlacek, F Vit, J Langrova, J Szanyi, Z Kubova (Faculty of Medicine, Czech Republic; e-mail: kubova@lfhk.cuni.cz)

Electrophysiological examination of visual perception with the use of visual evoked potentials (VEPs) is based so far almost exclusively on a central stimulation, since standard pattern stimuli are not enough effective to produce VEPs outside central ca. 20° of the visual field. However, when a visual motion stimulation is used, reactions to peripheral stimuli are well recordable, surprisingly mainly in the fronto-central cortical brain areas. These VEPs are namely not related so much to visual information processing, they represent predominantly significant event related reactions. With adequate arrangement of the motion stimuli in periphery (in such a way that they do not interfere with normal activities of subjects), it could be possible to perform a long-term monitoring of brain activity and to evaluate a level of visual information processing or vigilance in situations where signalization of critical changes is required (mobile visual simulator is a subject of the Czech patent application No. PV 2010–545). [Supported by Charles University—Faculty of Medicine in Hradec Kralove, Czech Republic (PRVOUK).]

◆ **Electrophysiological study of congenital prosopagnosia**

- 64 M Zimmer, K Nemeth, G Kovacs (Budapest University of Technology and Economics Dept of Cognitive Science, Hungary; e-mail: gkovacs@cogsci.bme.hu)

Congenital prosopagnosia (CP) is a long-life impairment in face recognition despite normal low-level visual processing. Previously several case studies investigated different aspects of CP. However, there are no complex studies describing the whole neuropsychological, behavioural and electrophysiological profile of these subjects as of yet. The goal of the present study was to investigate the face specificity of the N170 component in CP patients (3 members of a family—father, son, and daughter) and in age-matched controls. Subjects performed a face–non-face categorization task for 5 categories of stimuli (faces, inverted faces, shoes, chairs, and Fourier images /NOISE/). When comparing the N170 component to FACES and NOISE we have found a significant amplitude reduction and a reduced inter-trial coherence (ITC) for NOISE stimuli in controls. In CP, however, no differences were found between these conditions. Surprisingly, the face evoked N170 was similar in CP and controls. Moreover, both ERP and ITC for NOISE correlated with the performance of the individuals in the face recognition tests (CFMT and PFPB). Our results suggest that it is the processing of the noisy stimuli that is altered in CP.

◆ **Temporal dynamics of responses to dark and light stimuli in visual cortex**

- 65 S J Komban, J Jin, Y Wang, R Lashgari, J Kremkow, Q Zaidi, J Alonso (SUNY college of Optometry, USA; e-mail: jkomban@sunyopt.edu)

Recent physiological and psychophysical studies demonstrate a dominant representation of darks at early stages of visual processing. Here we investigate the response temporal dynamics of this dark dominance at the input layers of the cat visual cortex using a 16/32 channel multi-electrode array. We measured the response time course of each cortical site using white noise (WN) stimuli (224 ON, 424 OFF). Cortical neurons in layer 4 had shorter response latency to dark than light stimuli, however, the response to lights were faster at the response decay time and at the rebound suppression that followed the decay.

Finally, consistent with our human psychophysical measurements, responses for dark targets were faster than light when presented on uniform binary WN background. However, this temporal advantage is abolished when dark pixels in the WN background was increased to 70%. Overall, we demonstrate that V1 responses to dark and light stimuli differ in latency, time of response decay and rebound suppression. In addition, we find that the latency advantage for darks disappears when the proportion of background dark pixels approaches the value at which detection time is similar for darks and lights in humans.

◆ **Effect of central vs peripheral optic flow stimuli on postural responses revealed by surface electromyography**

66

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While retinal optic flow (OF) is considered a major cue for self-motion and postural stability, it is still debated the relative importance of central vs peripheral vision in visuo-postural responses. Psychophysical studies, by assessing the body sway in response to OF stimuli give more importance to visual periphery as source of compensatory postural responses, while the central vision would play an accessory role. Aim of this study was to verify the different influence of central vs peripheral optic flow stimulation on the activation of lower limb postural muscles: bilateral tibialis anterior and gastrocnemius medialis. Surface EMG was recorded in 24 male and female participants while radial (expansion and contraction) OF stimuli were presented either in a central or peripheral region of a wide screen. The activity of the right tibialis anterior was the most affected by OF stimuli. We found an interaction of sex by muscle in favour of male subjects (78%). The majority of the subjects had a greater postural response for either central or peripheral stimulation, meaning that the influence of visual field region on visuo-postural balance may be subject-specific, probably depending on other stimulus parameters.

POSTERS: HAPTICS

◆ **Haptic perception of force magnitude and force direction**

67

F E van Beek, W M Bergmann Tiest, A M Kappers (Helmholtz Institute, Utrecht University, Netherlands; e-mail: F.E.vanBeek@uu.nl)

In visual perception, stimulus direction often influences perceived intensity. In haptic perception, this phenomenon has also been observed, for instance in the radial-tangential illusion (Davidon et al, 1964 *Quarterly Journal of Experimental Psychology* **16**(3) 277–281). Haptic devices are increasingly being used in tele-operation systems, but they still lack haptic force feedback that feels “natural”. To improve this, it would be useful to know the relation between perceived force magnitude and force direction. This relation has been investigated in discrimination tasks showing the resolution of perceived force direction (Barbagli et al, 2006 *ACM Transactions on Applied Perception* **3**(2) 125–135) and magnitude (Vicentini et al, 2010 *ACM Transactions on Applied Perception* **8**(1) 1–16). However, tasks showing the (an)isotropy of force perception have not been performed yet. Therefore, the goal of this experiment was to establish the relation between perceived force direction and magnitude. Subjects were presented with a range of force magnitudes at a range of directions. They had to estimate the magnitude and direction of the force. Preliminary results suggest that force direction influences force magnitude perception. They also suggest a distortion in the perception of force direction. [This research is supported by the Dutch Technology Foundation STW.]

◆ **The development of position and force cues in haptic shape perception**

68

G Baud-Bovy, G Sandini, M Gori (Istituto Italiano di Tecnologia, Italy;
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Both the finger position and the contact force provide information about the shape of a surface that is manually explored with the fingertip (Robles-de-la-Torre and Hayward, 2000). Previous research has linked relatively late age-related performance improvement in various perceptual tasks to the development of cue integration, both across sensory-modalities (Gori et al, 2008) and within the same sensory modality (Nardini et al, 2010). In this study, we measured the absolute thresholds of 7 to 10 year old children and adults in a haptic curvature perception task. Participants judged the convexity/concavity of a virtual surface rendered with a haptic device where the position and force cues were systematically manipulated. We found that the performance improved markedly with age in all conditions and that the position cue dominated the force cue in all age groups. Noticeably, the relative weight of the force and position cues varied little across age groups. These results suggest that the marked age-related improvement of performance is probably due to an increase of the reliability of both cues with age.

Thursday

◆ **Quantifying haptic exploratory procedures by characterizing hand dynamics and forces**

69 S E Jansen, W M Bergmann Tiest, A M Kappers (Utrecht University, Netherlands;
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Numerous studies investigating eye movements during visual scene exploration propose a strong link between the type of movement made by observers and the task they were given. Analogous to this approach in vision, one can study hand movements during haptic scene exploration. Lederman and Klatzky (1987 *Cognitive Psychology* 19 342–368) proposed a number of exploratory procedures (EPs) that describe links between desired object knowledge and hand movements that are performed to gather the appropriate information (eg, ‘lateral motion’ to establish roughness). From these qualitative descriptions we propose a model that can be used to discriminate between several EPs using hand forces and dynamics. The model is based on variables such as orientation, speed, force, and exploration area. From these, objective measures are devised such that a weighted sum of the scores on each can discriminate between the following EPs: ‘contour following’, ‘lateral motion’, ‘pressure’, and ‘static contact’. With such a model, it is possible to examine the link between a certain EP and the desired object knowledge it is presumed to assess. We evaluate its ability to predict the correct object property based solely on participants’ hand forces and dynamics during a discrimination task in a 2D haptic scene. [This work was supported by the European Commission with the Collaborative Project no. 248587, “THE Hand Embodied”.]

◆ **From which viewpoint is hand movement represented in 3D object manipulation?**

70 J Liu, H Ando (Multisensory Cognition and Computation Lab, Universal Communication
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People can effortlessly integrate visual and somatosensory information to provide the right motor command, but how we code the different sensory inputs into a coherent interpretation is not clear yet. To investigate situations where visual and haptic information is spatially separated and/or rotationally misaligned may shed a light on this issue. In our previous work (Liu and Ando 2011 *i-Perception* 2(8) 937) we studied 3D object manipulation performance in a misalignment setting, in which subjects were asked to look forward while the hand was at the height of the stomach. Subjects’ performance was closer to that of co-location condition if the visual image of their hand was provided from the looking-down viewpoint. To investigate whether the looking-down view is critical to object manipulation performance in any eye-hand de-located settings, the eye and hand positions were reversed, that is, subjects were asked to look down while the hand was at the height of the eye. The result showed that the orientated hand movements were facilitated more by the image from the straight-forward viewpoint compared with the looking-down viewpoint, which suggests that the mental representation of hand movement may be constructed from the viewpoint that people look at the hand in their current posture.

◆ **Signal detection study of the effect of sound on the discrimination of hardness**

71 Y Suzuki, T Okuyama, M Tanaka (Tohoku University, Japan; e-mail: yuikasuzuki@gmail.com)

We aimed to explore the contribution of perceptual and decisional factors to the effects of sounds on the haptic perception of hardness by using a signal detection analysis. Previous research has showed that a contact sound provides the material perception of an object, and a valid determinant of the perceived material is a decay parameter. We investigated whether stimulus congruency between haptic and auditory information affects the effect of sounds on perceived hardness by using two pairs of silicone pieces that varied in stiffness and two synthesized contact sounds that contained different decay parameters. Participants were asked to differentiate between the harder and softer silicon samples. When they tapped on silicon, the auditory stimulus with a long or short decay time was presented simultaneously, or not. The results showed that the sounds modulated the discrimination sensitivity (d') and shifted the criterion (c), depending on the difference between the decay parameters of the sounds but not on the stimulus congruency. Our results indicated that sounds affect haptic hardness discrimination at the perceptual and decision level, depending on the relationship between the time of sensing the hardness and the decay time of sounds.

◆ **Haptic spatial constancy for object motion**

72 L Dupin¹, V Hayward², M Wexler¹ (¹Laboratoire Psychologie de la Perception, CNRS &
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Pierre et Marie Curie, France; e-mail: lucile.dupin@parisdescartes.fr)

In vision, spatial constancy is the phenomenon that when our eyes or body move, we perceive objects in an external or spatiotopic reference frame, independent of our own movement, even though visual

information is initially retinotopic. Spatial constancy seems to require some sort of compensation of retinotopic signals to take into account the observer's movements. In haptic perception, a similar problem can be posed: are objects perceived in a cutaneous reference frame, or are their positions and velocities compensated by information about our body's configuration and movement, resulting in haptic spatial constancy, ie, perception in a spatiotopic reference frame. Here, we investigated haptic spatial constancy for motion. We used a tactile display in contact with a fingertip, mounted on a mobile platform. While the finger moved along a line, an object moved in various directions with respect to the fingertip. Subjects reported perceived orientation of motion, from which we could deduce the degree of compensation for motion of the finger in space. We found some evidence for compensation, but this compensation is partial at best, implying strong haptic spatial under-constancy.

◆ **Grasping a shape with uncertain location**

⁷³ M Di Luca, T E Vivian-Griffiths, J L Wyatt, C Zito (University of Birmingham, UK;
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Successful grasp planning requires an appropriate finger placement for which object geometry and location need to be known. Here we investigate how position uncertainty and shape influence the selection of a two-finger pinch grasp. Elliptical cylinders were stereoscopically presented in rapid succession. The position of each cylinder was randomly selected using two orthogonal Gaussian distribution whose orientation changed at each trial. The axes of the elliptical base were aligned with these orthogonal directions. Participants reported the grasp they deemed more likely to be successful. In randomized trials the variance of the Gaussian distributions and the shape of the cylinders varied. Results show an interaction between position uncertainty and shape resulting in a combination of two strategies; (1) grasp is aligned with the direction of maximum position uncertainty and (2) grasp is aligned with the minor axis of the elliptical base. In conditions where ellipses are aligned with the maximum uncertainty, there is a trade-off between the two strategies that depends on magnitude and uniformity of position variability and on cylinder's eccentricity. Overall, participants seem to maximize the chance of actually reaching the objects while also trying to pinch them along the minor axis (ie, as in a stable grasp).

POSTERS: MODELS AND THEORY

◆ **Experiment toolbox: an approach to intuitive experimental design and programming**

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Nowadays, most visual experiments are conducted with the aid of computers. The programming of said computers is left for the experimenter. Libraries and toolboxes do exist to support the scientists by and large, but in the end, the task of developing the software running their specific experiment is left to themselves. Our Experiment Toolbox (ETB) defines a set of development tools that pick up the experimenters from a point of view they understand best: The methodical description of the experiment itself. At the same time, the ETB avails existing backends for speed and accuracy, thereby relying on the stability of proven frameworks. Definitions for constants and variables are put in the ETB human-readable and are easily edited. While the constant parameters of the experiment are stored in text files as key-value pairs, the independent variables of the experiment are listed in tabular form, where each column represents a variable and each line one trial of the experiment. This intuitive storage reflects the idea behind an experiment, to explore certain conditions of a given problem. The experiment's structure is defined with a simple set of functions in the backend's language. The functions represent the mindset of the experimenter, letting him define displays and measurements—the same way the experiment would be described in a paper. Simultaneously, the ETB does not hinder the experimenter by occluding the underlying programming language. The ETB furthermore defines interfaces for providing interchangeable code collections. The current implementation of the ETB provides all functions needed to interact with the files for parameters and the experiment structure and ensures the correct execution of the so defined experiment. It is written in MATLAB and relies on the established Psychophysics Toolbox for display handling and timing.

Thursday

◆ **A neural network model of perceptual grouping ability for 2D patterns**

- 75 M P Penna¹, A Montesanto², E Pessa³ (¹Dipartimento di Pedagogia, Psicologia, Filosofia, Italy; ²Dipartimento di Ingegneria Biomedica, Elettronica e Telecomunicazioni, Italy; ³Dipartimento di Psicologia, Italy; e-mail: eliano.pessa@unipv.it)

This contribution reports about a number of computer simulations of the behaviour of a model of emergence of perceptual grouping ability. This model is a simplified version of a neural network model of visual cortex operation already proposed some years ago by Grossberg and coworkers and belonging to the class of LAMINART models. Relying on previous simulations, performed on 1D patterns, we studied the case of 2D patterns, in order to evidence the influence of model parameter values on perceptual grouping ability. The simulations evidenced the crucial role played by a particular parameter modulating the strength of the signal coming from the input layer to an intermediate layer of inhibitory cells. The value of this parameter is critical in allowing the existence of perceptual grouping ability. It is possible to speculate about the possible adaptive origin of the allowed values of this parameter in biological vision systems. References: Leveille, Versace, Grossberg, 2010 "Running as fast as it can: How spiking dynamics form object groupings in the laminar circuits of visual cortex" *Journal of Computational Neuroscience* **28** 323–346. Yazdanbakhsh, Grossberg, 2004 "Fast synchronization of perceptual grouping in laminar visual cortical circuits" *Neural Networks* **17** 707–718.

◆ **Variability in pupil size during a cognitive task using nonlinear dynamics analysis**

- 76 O Lago¹, G Ginani², S Pompeia², P Schor³ (¹Ocular Bioengineering-Ophthalmology Dept—UNIFESP/ESEF-Jundiaí, Brazil; ²Dept of Psychobiology—UNIFESP, Brazil; ³Ocular Bioengineering-Ophthalmology Dept—UNIFESP, Brazil; e-mail: pschor@pobox.com)

Measuring the dynamics of pupillary motility is a challenge for many researchers due to its nonlinear behavior and produce many outliers and noise. Our goal is to introduce method to analyze the variability in pupil size during the cognitive task. From the data vector $X = (X_1, X_2, \dots, X_{n+1})$, we define the auxiliary vectors $x = (x_1, x_2, \dots, x_n)$ and $y = (y_2, y_3, \dots, y_{n+1})$, which are analyzed in ordered pairs (x_i, y_i) . Taking as reference the line $y = \tan(\pi/4) * x + 0$, we measured the perpendicular distance from each pair (x_i, y_i) to the line, and calculate its dispersion by the standard deviation (SDa). Also calculate the standard deviation of the points perpendicular to the line $y = \tan(3\pi/4) * x$. The SDa estimates the variations of the points in successive intervals (short-term variation) while SDb estimates the dispersion of points along the line of reference (long-term variation). We analyzed subjects performing Random Number Generation test and compare the pupil size during the test with the baseline, we evaluated their responses by parameters SDa and SDb. The results showed that there were consistent changes in these parameters associated cognitive exertion, suggesting a pupillary dynamics, with variations of short and long term well-defined. There are reasons to believe that the method is promising for analysis pupillary in cognitive tasks. [Supported by FAPESP(2010/00455–0) to PS, OCL, and (2011/01286–0) to GEG, SP.]

◆ **Cooperative dynamics of motion binding**

- 77 G Aguilar¹, M Mattia², P Del Giudice², A Pastukhov¹, J Braun¹ (¹Dept of Cognitive Biology, Otto-von-Guericke Universität, Germany; ²Istituto Superiore di Sanità, Italy; e-mail: jochen.braun@ovgu.de)

Many aspects of visual perception are characterized by 'cooperative behavior' such as order-disorder transitions, multi-stable states, and 'hysteresis' (Williams, Phillips, Sekuler, 1986 *Nature*), presumably reflecting recurrent excitation and inhibition within the underlying neural populations (Buckthorpe, Kim, Wilson, 2008 *Vision Research*). We have studied hysteresis in the transition between ordered and disordered percepts induced by random-dot-kinematograms (RDK). Our aim was to establish the probability and dynamics of order-disorder transitions and to characterize their dependence on the number of display elements (dots). Six observers viewed continuous RDK for 5 s—during which the fraction of orderly dots varied unpredictably (low-pass-filtered random walk)—and reported their initial and final percepts (orderly/disorderly). Orderly dots produced a coherent motion flow (clockwise or anti-clockwise, converging or diverging spirals, varying angular velocity). We obtained pronounced hysteresis for 'orderly fractions' from 0.4 to 0.6. Random walks terminating at 0.5 consistently yielded different percepts, depending on the orderly fraction 1 to 2 s prior termination, revealing a surprisingly pronounced influence of prior history. We introduce a novel method for characterizing the cooperative dynamics of order-disorder transitions in motion binding. These observations provide powerful constraints for abstract neural models based on discrete stochastic integration (Braun, Mattia, 2010, *NeuroImage*).

◆ **Did I do that? Causal inference of authorship in goal-directed actions for impoverished stimuli**

78

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The perception of own actions is affected by visual information and internal predictions (Wolpert et al, 1995 *Science* **269** 1880–1882). Integration of these cues depends on their accuracies (Burge et al, 2008 *Journal of Vision* **8** 4:20) 1–19), including the association of visual signals with one's own action or with unrelated external changes (Körding et al, 2007 *PLoS One* **29**). This attribution should thus depend on both consistency between predicted and actual visual consequences and their signal accuracy. Methods. We used a virtual-reality setup to manipulate the consistency between pointing movements and their visual consequences. We investigated the influence of this consistency on self-action perception for varying visual accuracies. We asked whether a causal inference model accounts for the empirical data, assuming a latent authorship-variable: if the visual stimulus was attributed to one's own action, visual and internal information should fuse in a Bayesian optimal manner. If the stimulus was attributed to external influences, there should be no fusion. Results and Conclusion. The model, fitted to the motor responses, correctly predicts authorship ratings, showing attribution of visual signals to one's own action for small, and stronger reliance on internal information for large deviations. Presently, we test predictions of the model for a variation of the accuracy of the visual information. [This work was supported by: BMBF FKZ: 01GQ1002, EC FP7-ICT grants TANGO 249858, AMARSi 248311, and DFG GI 305/4–1, DFG GZ: KA 1258/15–1.]

◆ **Spatial remapping during combined eye and body motion**

79

I Clemens, L Selen, W P Medendorp (Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, The Netherlands; e-mail: ivar.clemens@donders.ru.nl)

A typical characteristic of human vision is that the position of the retina is constantly changing due to eye, head, or body movements. These changes cause the retinal image to shift. Recent studies on the retinal image shifts caused by saccades have suggested that the brain corrects for these perturbations by remapping the neural image. To date, it is not known how and to which extent this spatial remapping is implicated during whole-body motion. We used a novel 2AFC paradigm to investigate this question. Participants ($n=8$) were translated sinusoidally (15 or 30 cm, 1.6 Hz) in lateral direction while fixating a stationary point. When the direction of motion reversed a reference LED was presented (50ms). At the next motion reversal, a probe LED was flashed and participants had to judge its position (left or right) relative to the remembered reference. We found systematic biases in the spatial updates, which depended on the retinal location of the reference LED. Furthermore, the bias was in opposite directions for references presented in front versus behind fixation. We show that our results can be explained by a gaze-centered model, with an underestimation of translation amplitude.

◆ **A new measure of motor-estimated size early in the grasp**

80

R M Foster¹, J Vanlier², V H Franz¹ (¹University of Hamburg, Germany; ²Eindhoven University of Technology, Netherlands; e-mail: volker.franz@uni-hamburg.de)

Foster and Franz (VSS 2012) demonstrated a mathematical side-effect of aggregating grasping trajectories: Temporal noise creates misalignment of the trajectories, which induces a dependence of grip aperture variability (ApVar) and aperture velocity (ApVel). Consequently, ApVar at early time points (when the fingers are opening and ApVel is large) must be higher than at later time points (near the maximum grip aperture, when ApVel is small). This presents a problem for studies that used ApVar to investigate whether Weber's Law exists early but not late in grasping, because only at early time points does ApVel and therefore ApVar depend on object size. An alternative approach is therefore necessary to compare early and late time points. We fit a simple force-inertia based grasp model to trajectories of $N=18$ participants and used the resulting parameter estimates as dependent variables. We discovered that, after an initial acceleration period, a constant velocity is reached which varies linearly with object size, similar to MGA. This is achieved quite early in the grasping movement. We therefore suggest using this model-based parameter as dependent variable when discerning motor-estimated size at early time points. We also apply this method to the original questions related to Weber's Law.

Thursday

◆ **The abstraction of visual numerosity from continuous visual properties**

81 I P Stoianov¹, M Zorzi² (¹Dept of General Psychology, University of Padova, Italy; ²Dipartimento di Psicologia Generale, University of Padova, Italy; e-mail: ivilin.stoianov@gmail.com)

Visual numerosity estimation is an evolutionary ancient ability foundational to mathematical learning supported by an Approximate Number System (ANS; Nieder and Dehaene, 2009 *Annual Review of Neuroscience* **32** 185–208). Based on novel results about the influence of continuous visual properties on numerosity estimation, Gebuis and Reynvoet (2012 *JEP:General*) suggested that number-judgment is the result of the weighting of several distinct visual cues and challenged the ANS hypothesis. We investigated this issue with our neurocomputational model of ANS (Stoianov and Zorzi, 2012 *Nature Neuroscience* **15** 194–196) in which numerosity is an emergent high-order statistical image property coded by specialized number-sensitive neurons. Here we show that the model can perfectly account for the data of Gebuis and Reynvoet. At the same time, we demonstrate that the response of the model's numerosity detectors is largely invariant to both cumulative surface and occupied area, consistent with neurophysiological data (Roitman, Brannon, and Platt, 2007 *PLoS Biology* **5**e208). Thus, the modulations induced by continuous visual cues do not challenge the notion of abstract coding of numerosity in the ANS and are in agreement with the "Visual Number Sense" hypothesis (Burr and Ross, 2008 *Current Biology* **18** 424–428).

◆ **A contrast energy model for numerosity coding by human observers**

82 S Raphael, B Dillenburger, M Morgan (Max-Planck Institute for Neurological Research, Germany; e-mail: Sabine.Raphael@nf.mpg.de)

We investigated the ability of human observers to discriminate and identify differences in numerosity, size or texture density between a test and a standard pattern. In the first experiment the patterns had an approximately circular envelope and the standard contained 64 dots. The number of dots in the test was altered by changing either the radius (size) of the pattern or the dot density. Changes in size were more accurately reported than changes in density. Numerosity changes were no better reported than changes in density. In a second experiment the shape outlines consisted of irregular polygons, making size estimation more difficult. Size discrimination thresholds were raised relative to those in experiment 1 but those for density and numerosity were little affected. Changes in density could be accurately discriminated from changes in size. The data were fitted by a model in which number is computed from size and density and an unsigned 'Max' rule is used to decide whether size or density had changed. We also considered a mechanism for numerosity based on the quantity of 'stuff' in the texture, computed from the contrast energy integrated over spatial-frequency tuned channels.

◆ **Dynamic scenes as an experimental tool to provide behavioral evidence for a**

83 **Coarse-to-Fine processing sequence during scene categorization**

L Kauffmann¹, B Musel¹, N Guyader², C Peyrin¹, A Chauvin¹ (¹LPNC, UMR-5105, Grenoble Université, France; ²GIPSA-lab, CNRS—UMR 5216, Grenoble Université, France; e-mail: Alan.Chauvin@upmf-grenoble.fr)

Studies agree that visual scenes are analyzed by the visual system in terms of spatial frequencies following a predominant coarse-to-fine (CtF) processing (low spatial preceding high spatial frequencies). In Musel et al, (submitted *PlosOne*), some results provided behavioral evidences that scene categorization was facilitated when scenes were displayed in a dynamic sequence following a CtF sequence compared to a fine-to-coarse (FtC) sequence. They used a bank of Gabor-like filters to decompose scenes in different spatial frequencies and they built dynamic sequences presenting the same filtered scene in different spatial frequencies either in CtF or FtC sequence. In this study, 72 participants performed a categorization task (indoor vs outdoor scenes), using dynamic scene sequences, in which they resorted to either CtF or FtC sequences. Ten different types of sequences were built using different filters, central frequency samplings, normalizations and also, different durations for the filtered images that composed the dynamic sequences. Results showed that participants categorize CtF sequences more quickly than FtC sequences when sequences were built with constant band-pass filters, with the null frequency removal and normalization of the filtered scenes. These dynamic scenes seem therefore well appropriate to highlight the neural substrates of the CtF categorization of scenes.

◆ **Comparisons of static and dynamic paradigms to investigate the Coarse-to-Fine categorization of scenes**

84 J Bourgin¹, C Maire¹, L Kauffmann¹, A Chauvin¹, N Guyader², C Peyrin¹ (¹LPNC, UMR-5105, Grenoble Université, France; ²Gipsa-lab, France; e-mail: Carole.Peyrin@upmf-grenoble.fr)

Visual scene perception seems to be based on a Coarse-to-Fine (CtF) process where low spatial frequency luminance is rapidly extracted followed by higher spatial frequency chromatic information. However, a question still remains: The quality and quantity of information displayed in a filtered scene could favor low frequency oppose to other frequencies band. These studies used filtered scenes in different spatial frequency bands in order to disentangle the information available from the diagnostic information. We evaluated the contribution of different spatial frequency bands through several dynamic and static paradigms on scene categorization. Participants performed a categorization task (indoor vs outdoor scenes), using static scene with 6 different spatial frequency content and dynamic natural scene sequences (in this case they resorted to either a CtF sequence or a reverse FtC sequence), displayed during 150 ms. Our results showed that diagnostic information resides in the middle frequency even though low frequency band is sufficient for an effective categorization. Thus, CtF strategy seems to be a mandatory processing but visual system capacities (Musel et al, in press, *PLoS One*), perceptual constraints (Mermillod et al 2005 *Brain and Cognition* **58**(2) 246–248) and task demands (Schyns and Oliva 1997 *Perception* **26** 1027–1038) modulate the diagnosticity of specific spatial frequency bands.

◆ **The role of higher-order statistical dependency of natural images in visual perception**

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In recent studies on computational vision from the efficient coding viewpoint, it assumed that visual sensory neurons are adjusted to the statistical properties of natural environment during sensory evolution. Thus understanding the statistics of natural images can help us to comprehend the function of visual sensory processing and perception. Natural images have non-random structures that reflect causal differences in the world. However, decorrelated natural images contain obvious structures but many of the important forms in the natural images require higher-order statistics to describe. It has been demonstrated that higher-order statistical structures of images are basis for the visual perception and object recognition and investigating such regularities could assist to clarify the spatiotemporal function of neurons in V1 and beyond. Nonetheless, higher-order statistics properties of natural scenes and their representation in the neural population are still unclear. In this study we extract spectra features from natural vs non-natural images by using statistical methods to construct an statistical model of natural image space. Our findings indicate that there are some significant differences between natural images and random spaces which are critical for visual perception. Our results will be useful for optimal modeling of visual system and can help to develop hierarchical models for learning non-linear regularities in natural images.

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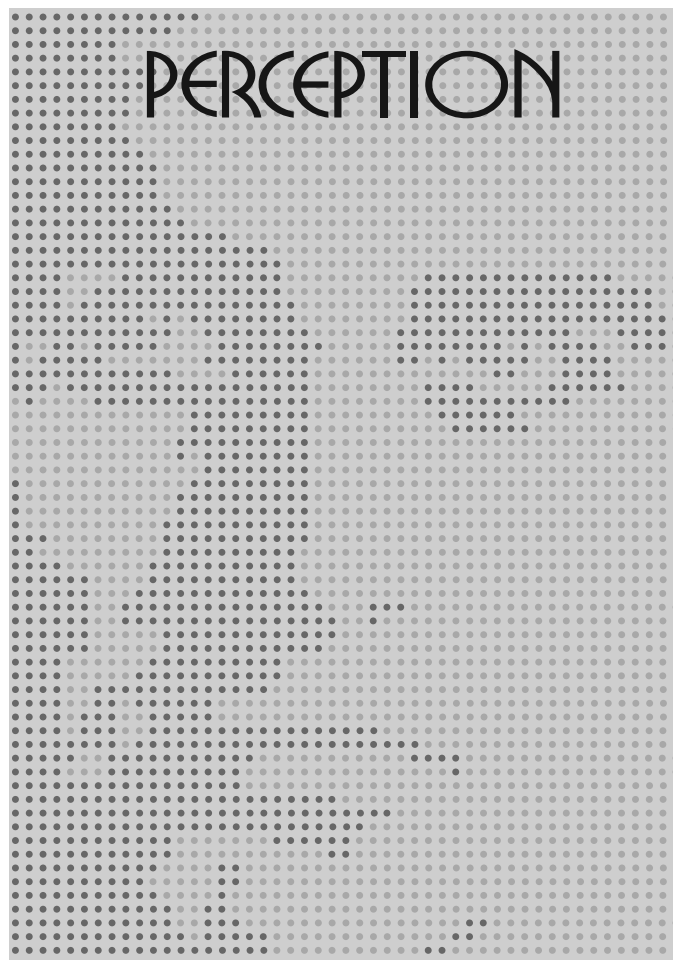
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